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## THE CONTRIBUTION OF MEDICAL SCIENCE TO MEDICAL ART AS SHOWN IN THE STUDY OF TYPHOID FEVER[1]

I INTERPRET the gratifying invitation of the Academic Senate to appear before you as faculty research lecturer for the current year not only as an opportunity of assembling and correlating a group of facts that I have been studying, but also as allowing me to attempt an explanation of the method by which such facts are obtained. I wish in particular to suggest how one of the more theoretic or so-called scientific branches of medicine is utilized in the practical problem of preventing and curing disease.

There is little reason that many of you should have attempted to differentiate between medicine as an art and medicine as a science. Public interest and concern in medicine deals with it largely as it is applied to the individual or community and little with the scientific and more theoretic investigations on which the progress of applied medicine depends. Medicine to the layman is typified in the physician who attends him and it is the noble and satisfactory function of this individual to ease the mind and body of his patient and frequently so to apply his knowledge of human structure and function in health and disease as to avert death and hasten recovery. The practitioner employs the art of medicine, that is to say he combines, modifies and adopts certain recognized means to

[1] The annual faculty research lecture at the University of California, delivered on Charter Day, March 23, 1916, on invitation of the Academic Senate.

effect a given end. There exists, however, a type of work in medicine with which the public comes less in contact and which concerns itself primarily with the fundamental understanding and elaboration of those very means of prevention, relief and cure which the physician applies.

It would naturally occur to you that the individual best fitted to discover means of understanding and thereby of combating disease, would be one fully conversant with its manifestations and results through constant and persistent contact with the sick. Such, indeed, was the development of medical science through many centuries. I need only mention categorically a few of the great discoveries that have been made during the centuries by practising physicians. Galen, in the second century of our era, showed that control of the muscles depends on integrity of the nerves that run to them, by the simple experiment of cutting certain of them in animals. In the sixteenth century Versalius not only founded the science of anatomy, but described the mechanism of breathing and introduced artificial respiration. Harvey in the seventeenth century experimentally demonstrated the mode of circulation of the blood in the animal body. Thomas Young laid the foundation of physiological optics and explained the principle of color differentiation. Jenner showed conclusively that inoculation with cowpox will protect against smallpox, and thereby laid the foundations of vaccination as a preventive of many infectious, parasitic diseases. Morton, in the last century, discovered the principle of anesthesia, which has made surgery painless.

You will notice that these examples consist entirely of contributions which may be regarded as fundamental principles rather than adaptations of such principles, however practically valuable; in other words, it is a list of discoveries rather than of inventions; on such basis I have omitted Lister's great application of Pasteur's principles of bacterial contamination in aseptic and antiseptic surgery. You may further observe that the contributors cited have worked on experimental rather than purely deductional lines; I have not, for instance, mentioned the important work of Auenbrugger, who associated certain percussion notes over the chest wall with diseased conditions in the lungs and heart. I trust I shall be able to convince you that essential advance in medicine, as in other biological sciences, lies in the development of principles through inductive experimentation.

In the popular mind and in popular fiction it is still the well-known practitioner who is the great contributor to medical science. As a matter of fact to-day, and for many years, the progress has been largely due to a group of workers who are concerned little, or often not at all, with the care of the sick. Many major discoveries have been made by men with no medical training at all. I may simply mention among the latter Pasteur and Metchnikoff, whose contributions we shall later consider in more detail. This differentiation in medicine of a group of medical or even non-medical men from medical practitioners, is a specialization or division of labor that is unknown to or misunderstood not only by the general public, but even in the medical profession itself. Its development is, however, quite logical and tending toward greater efficiency.

Progress in medical treatment a hundred years ago, and to a great extent fifty years ago, depended almost entirely on deductions that were ingeniously made from personal experience with the sick. The greater such an experience was the greater and more complete the series of facts obtained, the more valuable the deductions from them. Nothing approaching a complete series of

facts, and particularly of facts in their chronological order, was possible until experimental methods were employed. As Neuberger has stated, collection and observation of fact constitute the first step in science, but not science itself. With the application of the methods that had already been utilized in the sciences of physics and chemistry to biology and medicine, it has often been possible not only to reproduce in animals some particular stage of a disease that has been met with in man, but to study the preceding and succeeding stages in such a process with a completeness that could be afforded in the sick room only through unlimited experience. Any deductions from the haphazard data of spontaneous disease requires, moreover, unlimited skill in fitting each stage as it irregularly occurs, into its proper place. Deductions from a relatively complete and orderly series of experimental facts are at once more rapidly arrived at and more reliable than empiricism. They have the further advantage of suggesting in their genesis other questions that have perhaps never arisen in clinical experience, the answers to which may, however, greatly simplify the problems of medicine.

When once the fruitfulness of the study of medical problems by methods already employed in the exact sciences became evident to the thoughtful physician, innumerable questions arose in his mind which he felt sure could now be answered. He felt, let us say, that animal experiments could tell him the exact relation between a shrunken and diseased kidney, a thickening of the arteries and an enlargement of the heart, a combination frequently found associated, and once the exact relation was known, particularly as to which came first, he felt some method of arresting or preventing the process might finally be obtained. At first the more ambitious and able practitioners endeavored to answer these questions for themselves, working in their laboratories into the still hours of a morning that ushered in another day spent at the bedside and the operating-table. These giants exist even to-day and it is owing to their example, enthusiasm and aid, that some of us are now able to carry on their work with greater single-mindedness and under less heroic conditions of existence. As the facts have accumulated and the methods of these newer sciences have been elaborated, it has become increasingly more difficult for one with divided interest to understand and particularly to add to them. Twenty-five years ago the professor of anatomy was a surgeon; the professor of pathology a practitioner of medicine. These men were often able and brilliant teachers of subjects which were their avocations rather than their true professions. They were even contributors to sciences which in their incompleteness made the finding of new facts easy. As the mass of acquired facts became larger, the gaps between them shorter but more difficult to fill, and the stimulus to further discovery greater, men one after another slipped from the beaten track of practise to become laboratory workers, usually at a financial sacrifice, because the work appealed to them.

It became evident that the medical sciences require whole-souled devotion. As Dietl expressed it in 1851,

> As long as medicine remains an art it will not be a science. As long as there are only successful physicians there will be no scientific physicians.

It is the practitioner, however, who has created the field for this latter type of worker and who, to a large extent, has made his existence possible.

We have had then for a number of years, two types of workers in medicine—the laboratory man and the practitioner; the

boundaries between them are by no means fast and one crosses readily from one into the other field, but with less and less frequency does one attempt to do both types of work at once. The relations between these workers are highly cooperative, and usually mutually appreciative. The practitioner, as the original patron of the medical sciences, was at first inclined to regard his laboratory colleague as a high-grade technical assistant, and, being closer to the source of human disease problems, he still at times assumes a somewhat ex cathedra attitude as to what problems the medical scientist should investigate. Concerning the actual method of investigation he has, through lack of experience, become tacitly acquiescent. The relation of these workers in regard to the problems themselves is an interesting one and worthy of fuller elaboration.

It is obvious that the practitioner, through constant contact with the sick, knows of more problems that need solution, but through failure to appreciate the limitations of scientific method he does not usually appreciate those problems which can be solved. The clinician is constantly asking the laboratory man for explanations or help that can not as yet be given, and is often surprised when he asks whether *A* and *B* in conjunction will produce a condition *C* to be answered evasively, or told that *D* equals *E*. The clinician has had the tables reversed on him and must perforce content himself with what is given him to apply and not ask for what he would like. A slight misunderstanding each in the other's point of view must arise when we consider the differences in the material with which each man has to deal. The clinician is interested primarily with the needs of individuals, with the problem of a case; the scientist with disease entities, with a complex composed of all the cases of a particular malady that have existed, or that may exist, or frequently with some more abstract line of investigation arising from them. In the first instance the problem, though acute, is a personal and passing one that in the particular case will disappear before the question that has arisen can possibly be answered; in the latter case the solution is acceptable however long it may be in coming. It is easy to understand the impatience of the clinician who wishes results in order that he may apply them to Mr. A, and on the other hand it is reasonable to appreciate the refusal of the laboratory man to be dragged from a promising problem of fundamental import to investigate superficially an ephemeral individual symptom. While it is still possible for the laboratory man to be influenced in choosing his problems, he travels fastest by following attentively those problems which his own work has suggested. It is often more profitable in the end to follow what appear to be irrelevant ramifications rather than to attempt direct determination, let us say of the cause of cancer, or a specific cure for tuberculosis. I venture to say that these questions will not be answered by what we consider direct attack, for it is the habit of nature to respond to our interrogations with apparent indirectness. The real indirectness of course lies in the way we put our questions and not in nature's response. We plan an experiment and await a result which shall be firmly yes or no; the answer is neither of these, but something that throws no light on the original inquiry. Blessed is the man who sees in this incomprehensible reply the starting-point of a new line of inquiry which may take him far afield from the goal he had first in mind. We scientists are like rag-pickers, some fumble through masses of rubbish looking for a certain coin, while the true investigator takes up each object that is

turned over and asks himself what use he can make of it.

Let me illustrate the stages in the evolution of modern medical science from medical art by an outline of the development of our useful knowledge in respect to a single disease, namely, typhoid fever.

Typhoid fever has been, and still remains, one of the significant causes of death and disability. So far as can be shown from the necessarily incomplete statistics of the Public Health Service, there were over 17,000 deaths from this disease in the United States in 1913, which means there were over 170,000 cases, since the mortality averages ten per cent. It is a malady particularly prevalent in crowded groups of men, such as armies and asylums. Sixty per cent. of all the deaths in the Franco-Prussian War were due to typhoid, and in the Spanish-American War one fifth of all the enlisted men contracted the disease, and there were seven times as many deaths from it as from implements of war. And typhoid fever is important not only as a cause of death, but particularly owing to its economic waste; for an acute disease it has a particularly lengthened course and is followed by frequent sequels. It has recently been estimated that the economic loss in this country from typhoid is $50,000,000 annually, as a disease ranking second only to tuberculosis.

Our interest in typhoid fever is heightened by the fact that it is not only an important disease, but one which can and will eventually be obliterated. Recent reports from the Surgeon-General of the United States Public Health Service show that the incidence of this disease is probably not more than half what it was thirty years ago, owing in large part to improved sanitation alone.

Perhaps the one most significant line of advance in medicine has been the gradual recognition of disease entities. On the recognition of separate diseases depends all measures of quarantine, prevention and rational therapy. Diagnosis, the recognition of a disease entity, depends on the patient's symptoms and these symptoms are of two classes; subjective, or those the patient himself experiences as pain, chilliness, and the like; and objective symptoms which the physician can detect. Among the latter may be mentioned rapidity of the heartbeat, fever, eruptions, changes in blood pressure; changes in the blood and urine, and the like. Medical progress has been dependent on the methods of recognizing such constant variations from the normal as are found characteristic of a given type of disease. Such variations were detected at first by the unaided powers of observation, and later by the employment of instruments and methods of precision introduced in the evolution of the medical sciences.

One of the most important symptoms of the parasitic or infectious diseases is a rise in bodily temperature, or fever. A fever is a disease characterized by such a rise in temperature and some fevers continue over a period of days or weeks. The disease we now recognize as typhoid or enteric fever is one of these continued fevers and, although probably seen by Hippocrates, was for centuries confused with other lasting fevers of somewhat similar appearance. Recurrent fever, septic infections, and typhus fever in particular present pictures which even to-day in their beginnings and in their purely clinical aspects may be confused with typhoid.

We owe our first full description of what was probably typhoid fever to an English physician, Thomas Willis, who in 1643 described an epidemic of the disease that occurred in the Parliamentary troops. Early in the eighteenth century Strother, another Englishman, described ulcerations in the

intestine and enlargement of the spleen in that slow nervous fever which we now recognize as typhoid. The effect of this disease in producing a cloudiness or aberration of the mind is what has given it its name, which is derived from the Greek τῦφος or cloud. Its particular nervous or mental effect was further observed by Huxham, who in 1737, on a purely symptomatic basis, separated cases of "putrid malignant fever" (or typhus) from the "slow nervous fever." The final separation of these two confused diseases did not come, however, until a century later and was dependent not only on the recognized differences in the contagiousness and course of the two diseases, but on the recognition of the characteristic and almost inevitable lesions or anatomical changes which are found in fatal cases of typhoid, but never in typhus fever. These lesions, ulceration of the intestine and swelling of the spleen, liver and lymph nodes, mentioned by Strother, were described by Riedel in Germany (1748), Baillie in England (1761) and in particular by Roderer and Wagler (1762). We owe further descriptions of the clinical characteristics of typhoid fever to Bretonneau (1826) who called it "dothienenteritis," or abscess of the small intestine, a name which it frequently bears in French literature, and to Louis (1829) who gave the name "fièvre typhoïde" to the malady.

It is to the great credit of a Philadelphian, William Gerhard, to have given in 1839 a convincing basis of separation between typhus and typhoid fevers. He based this differential diagnosis on accurate descriptions of the greater contagiousness of typhus, the presence of characteristic lesions in typhoid, and on careful comparison of symptomatic differences between the two maladies. His observations, later confirmed in Germany and England, gave us the first basis on which to regard typhoid fever as a separate and distinct disease entity.

The final chapter in the clinical or purely observational study of typhoid fever is represented by two important observations in reference to its transmission from one human being to another. The disease as contrasted with typhus fever was regarded, and properly so, as only slightly contagious, that is, directly transmissible from one patient to another. In 1856 Budd pointed out that the danger of transmission in typhoid, the poison of the disease as he expressed it, lies in the patient's excreta, and in 1873 Murchison actually traced an epidemic to a contaminated milk supply, and showed that the stools of typhoid patients are the principal source of danger in spreading the disease.

This brief statement then outlines the significant advances that were made over a period of centuries in the differentiation and recognition of typhoid fever by purely observational methods, confined to the patients themselves and made by practitioners of medicine. In so far as alleviation of the disease is concerned, there is little or nothing to report beyond purely symptomatic and palliative treatment, the most significant point in which was the introduction of hydrotherapy by James Currie in 1770 and its rediscovery by Brand a century later. The recognition of the danger of spreading the disease through contamination with typhoid excreta must be regarded as a great contribution to preventive medicine.

We come now to a period, which may be roughly defined as the year 1880, which ushered in the two most productive of the medical sciences, bacteriology and its twin sister, immunology. Whereas the experimental sciences of chemistry, physiology, and some aspects of experimental pathology, were already established and had made, and continued to make, valuable contributions to human welfare, bacteriology was destined to explain the causation of a series of dis-

eases known as infectious, and immunology to utilize these discoveries in the specific prevention and cure of many of them. The infectious diseases are not only important in themselves, but are recognized as indirectly the cause of many of the chronic diseases, so called, which are slower in their course, but none the less health-destroying and fatal in their outcome. The growth of bacteriology has been coincident with the filling of the ranks of our present army of laboratory workers, many of whom have been primarily concerned in advancing this science. Bacteriology owes its stable beginnings to two men, Louis Pasteur, a chemist, and Robert Koch, for a brief time a country physician and later professor of hygiene in Berlin. Immunology, the science which explains natural protection to infectious disease and utilizes this knowledge in creating such conditions artificially, we owe first after Pasteur to Metchnikoff, a Polish biologist with no exact medical training. It is characteristic of these sciences that their problems, although arising in cases of human and animal disease, have been developed, in large part, away from the bedside, under the conditions of greater accuracy and completeness afforded by the experimental reproduction of the disease in animals. Such an experimental disease may be interrupted and attentively studied in its successive stages and its course may often be followed outside the animal body under conditions of greatest clearness.

It was the great service of Pasteur, and particularly of Koch, to show that each one of an increasing number of infectious diseases is caused by a separate and identifiable type of microorganism. Such a microorganism is always found in each case of the disease in question, but in no other instance, and will give rise again to the same disease when reintroduced in a healthy animal of the same species. The first instances of infectious diseases studied, anthrax, typhoid, chicken cholera, tuberculosis, and others, were found to be due to minute plants called bacteria. Later observers have described similar infectious diseases due to equally lowly animal parasites, particularly to those known as protozoa.

Typhoid fever was one of the first of the human infectious diseases to yield the secret of its parasitic cause. The typhoid bacillus, *B. typhosus*, was first described by Carl Joseph Eberth in 1880, who found it microscopically in tissues from a patient that had died of typhoid fever. It was grown outside the body in pure culture four years later by George Gaffky. This organism was soon recognized as the cause of typhoid fever, although the final postulate necessary to prove the etiological relationship to the disease was not fulfilled until 1900, when Metchnikoff and Besredka succeeded in producing the disease experimentally with pure cultures in anthropoid apes. Of great corroborative importance in proving the causative relationship of the typhoid bacillus was its presence in the stools and urine of cases of typhoid fever, which was demonstrated in 1885. In the same year Fraenkel and Simmonds found the microorganism in the circulating blood of a case of typhoid fever, a condition which was later shown by the work of Kühnan (1897), Castellani and Schottmüller to be fairly constant during early stages of the malady. This observation not only proved finally and conclusively the etiological relation of the typhoid bacillus to typhoid fever, but led to a gradual reconstruction of our conception of the disease itself so that we have finally come to regard it primarily as a septicemia or blood infection rather than an intestinal disease *per se*, as the striking lesions in the small bowel had led us to assume.

A scientific discovery may be considered worth while if it merely gratifies intellectual curiosity and adds an apparently insignificant support to a structure, the totality of which makes for human knowledge and welfare. It is a characteristic of the medical sciences in general, and of bacteriology in particular, that the discovery of new principles has led very rapidly to practical results of the greatest significance to mankind. In no instance is this characteristic more strikingly true than in the study of typhoid fever. The study of *B. typhosus* as the single and essential cause of typhoid fever led rather rapidly to important advances in the prevention and cure of the disease.

I have already referred to the valuable suggestions of Budd and Murchison that the potential danger of contagion in typhoid fever lies in the excreta from patients. In common with all empirical results arrived at by retroactive judgment between cause and effect, these suggestions were only partly convincing and led to only partial avoidance of the danger. Witness, for example the obstinate assertion of Pettenkoffer, the great hygienist, who insisted that the contagion in this disease must pass through a ripening stage in the earth, and that its spread is dependent on the level of ground water. The demonstration that the typhoid bacillus was not only the cause of the disease, but that it is present in the stools and urine of typhoid patients, at once led to more logical and far-reaching avoidance of these sources of contagion. It was accepted not only that typhoid patients are a source of possible danger, but it was soon suggested that even after their recovery they might continue to retain the germs of the disease in their urinary bladder or intestines (Horton-Smith, 1900; Koch, 1902). This led, at Koch's suggestion, to a systematic investigation of the stools of recovered cases of typhoid fever in certain parts of Germany where the disease was particularly prevalent, and showed that four per cent. of all recovered cases remain "carriers" of *B. typhosus* for varying lengths of time, some of them for years. In connection with this study Drigalski made the important observation that a few individuals may harbor the typhoid bacillus in their intestines without ever having suffered from the disease, "healthy carriers" as they are called. Repeated observations in all parts of the world have shown that through contamination of foodstuffs, these carriers may produce not only a chronologically extended series of cases, but actual acute epidemics. The obvious remedy consists in detecting the innocent but dangerous individual and isolating or curing him.

Food contamination occurs not only in its preparation by carriers, but sometimes through transfer of the bacteria by flies, as has been shown to be the case particularly in asylums and prisons where excreta have been left exposed in the neighborhood of kitchens. Reed, Vaughan and Shakespeare have particularly emphasized this danger of fly transmission in their careful study of the devastating effect of the disease among our troops in the Spanish-American war. Evidence of this sort has led to an appreciation of the necessity of proper, protected latrines which can be rapidly built even in temporary camps.

These and other real contributions toward the prevention of the spread of typhoid fever have been made by pure bacteriology. Let us now consider what the sister science of immunology has accomplished. I have only suggested how much the demonstration of the typhoid bacillus in the blood or stools of a suspected case of typhoid may aid in diagnosis of the disease. As a matter of fact no diagnosis is complete or indeed certain without such examination. An even

simpler and almost as reliable method of laboratory diagnosis has been devised by Widal and by Gruber, depending on a principle that had been previously discovered in laboratory experiment. Bordet in particular is responsible for having shown that the blood serum of animals that have been given injections of a microorganism may be distinguished from the serum of normal animals by the fact that it clumps the microorganism in question. This fact was applied by Widal in his now famous test for typhoid fever, which depends on the presence of this agglutinating substance in the serum of those that are suffering from typhoid fever. This sign occurs in nearly all cases of the disease, although more frequently in its later stages.

Our present methods of protective vaccination against typhoid fever depend on principles that have been dimly appreciated but at times successfuly used by very primitive peoples throughout the centuries. It had been observed that those who recover from certain of the infectious diseases are thereafter protected from them. With this fact in mind the Orientals practised arm to arm inoculation with smallpox virus which usually produced only local evidence of the dread disease and was followed by protection from it. Jenner made this haphazard and dangerous method of prophylaxis a safe one by utilizing virus from a modified form of smallpox, namely cowpox, which is not only harmless, but gives equally good protection. Full understanding of the principle involved and its application to other infections, however, was dependent on the advent of bacteriology a century later. Pasteur not only separated out the causative agents of a number of diseases, but found that he could so modify their virulence that they no longer produced fatal or serious effects when reinoculated into animals. Those that had been treated with these modified germ cultures were found, however, to be protected against fully virulent original growths of the microorganism.

Facts such as these were early discovered in respect to the infections produced by the typhoid bacillus in small animals. Beumer and Peiper in 1887 found that mice that had recovered from a non-fatal dose of this organism would subsequently withstand doses that were fatal to their untreated brothers. Shortly after, following a very important discovery by two American scientists, Salmon and Smith, it was found that this same protection could be effected in animals by the previous injection of cultures of the typhoid bacillus that had actually been killed by heat.

In 1894 two German scientists, Pfeiffer and Kolle, on the basis of further theoretical studies, were led to try the effect of giving human beings small hypodermic injections of dead typhoid bacilli. They found that the doses they used produced certain uncomfortable but transitory symptoms, but that the blood of such treated individuals when subsequently examined contained antibodies which indicated that they were protected against typhoid fever. At the same time, and independently, A. E. Wright began similar inoculations in British soldiers who volunteered for the purpose. The inoculations did them no harm, and as larger and larger groups of these vaccinated men came into being and were subjected in war to the same dangers of typhoid infection as were untreated men in the same regiment, it became evident that they were much less likely to contract the disease than the uninoculated, and when such vaccinated men did at times come down with typhoid fever, the disease almost invariably ran a milder course than in the unvaccinated and the mortality among them was distinctly lower.

It took something over ten years to con-

vince the thinking world that preventive inoculation against typhoid fever is harmless and that to a striking extent it does protect. The results attained in the German and English armies and among the personnel of hospitals have assured us that these classes of people, who are the most exposed to typhoid fever, become, when vaccinated, only one half to one sixth as liable to contract the disease as the untreated. The protection, then, under these unfavorable conditions, is not absolute, but very evident. Much better results have been obtained in the last few years in the United States army, where, in spite of objection, typhoid vaccination has been made compulsory since 1910 for all men under forty-five years of age. Whereas in the preceding nine years there were on the average 351 cases of typhoid annually, since compulsory vaccination the cases have sharply diminished until in 1913 and 1914 there were only four and seven cases, respectively, a truly remarkable showing. These last results have been enough to convince the most skeptical, and have led to widespread adoption of the method, not only in armies, but in civil communities. These results in our army, life-saving, convincing and valuable as they have been, are open to a very slight objection in my opinion; they have led the public, and particularly the medical profession, to a slight over-confidence in the efficacy of the method itself. These army results are essentially perfect, at least far nearer perfection than has ever been reached by any similar type of biological preventive or curative treatment, a fact which leads us to suspect that they are exceptional and due to the operation of a set of conditions which, in spite of their existence over a considerable period of time, are not to be counted on.

Among the conditions that have operated in making these conditions more perfect is the vaccine employed and the method used in its administration. Army officials are, in my opinion, inclined to attribute an undue importance to this factor. They use a certain strain or race of the typhoid bacillus derived from England, to which they are inclined to attribute particular properties of immunization. Results elsewhere have indicated, and we believe we have strong evidence from unpublished work in our own laboratory, to prove that a vaccine compounded of a number of strains of the organism is better. The army has introduced three instead of the two injections which were formerly used in England, and this is an undoubted advance.

The fact remains, however, that the army vaccine, or at least vaccines prepared by commercial firms from the army bacillus under identical and simple conditions, do not invariably protect in civil life. Recent reports from the continental armies, each employing a different method, show that in none of them is the protection afforded nearly absolute, in spite of the fact that in parts of the French army four or five injections have been given. I am inclined to believe with Sawyer that the superior results in our army are largely due to the fact that the entire body of men has been protected, that there has been no single unprotected spot for an epidemic to get a start and gain in violence, to use a vague and perhaps not wholly accurate simile. Some recent results in France certainly indicate that antityphoid vaccination is more effective in those groups with the higher percentages of assuredly vaccinated men.

I have gone somewhat fully into this discussion of the army typhoid vaccine for the purpose of indicating that their results, although exceptional, have by no means convinced other authorities that the methods they employ are in detail the best. Let me emphasize again that we are not now

considering whether typhoid vaccination is of value, *that* you must accept as proved beyond peradventure, but just how valuable it is and in what way it may be further perfected. In other words I am leading you into those intricacies of detail which any scientific problem attentively considered must present, and from the unraveling of which new and important issues may arise.

Our former beloved professor of hygiene, George Reinhardt, came to me some three years ago and asked if I did not agree with him that the student body in this university should be offered the opportunity of being vaccinated against typhoid fever. With no hesitancy at all I answered "Yes." When he pressed me further as to the best method of preparing and administering the vaccine I felt unwilling to decide so important a matter on the basis of literary knowledge alone. In association with the late Dr. Edith J. Claypole we undertook to arrive at some conclusions on the subject. We found that nearly twenty different preparations of typhoid vaccine had been suggested, and each regarded by its author as the best. Data, however, on which to compare one vaccine with another were almost entirely lacking, that is to say a vaccine was approved because it had worked well under a given set of conditions with a more or less considerable number of men without any direct comparison with other vaccines.

Three distinct improvements in the vaccines in vogue seemed possible.

First: All vaccines were admitted to protect, at best, for only relatively short periods of time, say about two years.

Second: Many of the vaccines advocated were admitted to give rise, on administration, to rather uncomfortable transitory symptoms.

Third: The current method of administration, three injections over a period of three weeks or more, seemed an unnecessarily long period to wait for protection.

It was with these questions particularly in mind that we began our experiments. Out of them have arisen innumerable further questions, some of which have given rise to investigations of theoretical and practical interest. In the first place there had been no convincing experimental method of comparing the relative protective value of various vaccines. The only results of value seemed to be statistics from inoculated men obtainable only after years and under most uneven conditions. Certain experiments of Metchnikoff and Besredka with anthropoid apes were suggestive, but impossible to carry further, owing to the expense of these animals. We finally adopted an experimental procedure in rabbits that had been used for other purposes and which, with our modification of it, led us to conclusions that were rapidly obtained and apparently valid. It was found possible to compare several of the best typhoid vaccines in respect to the length of time they protected rabbits against infection with living typhoid bacilli. As a result of many experiments of this sort we came to the conclusion that a new type of "sensitized" vaccine, as it is called, gives rise to the most durable immunity. The word "sensitized" simply means that the bacteria in the vaccine have been treated with the serum of animals that have been highly immunized against them. It was furthermore found possible to remove certain toxic elements (endotoxins) from these vaccines with a further increase in immunizing property. The final product, then, a "sensitized vaccine sediment," as we call it, not only protects animals longer from infection than other vaccines, but is found when injected into human beings to produce little or no reaction.

Another improvement we have suggested is the administration of the customary three doses of vaccine within a week instead of the three weeks usually regarded as necessary. Here again careful experiments in rabbits showed us that this rapid method produces an equally efficient and lasting protection.

The final proof of the value of a preparation is of course in practise, that is to say, its actual protective value for human beings. The California State Board of Health has been supplying our vaccine for free distribution to physicians for the past two years. Dr. Sawyer, of this board, undertook to find out the results of typhoid vaccination in this state about a year ago. He obtained records from over 5,000 cases that had been treated with our vaccine, and something over half that number that had been treated with various other vaccines, mostly of the army type, as dispensed by commercial houses. There were about the same actual number of failures to protect in both series, that is, there were twice as many cases of typhoid fever per thousand among those vaccinated with other vaccines as with our own.

It is evident, then, from these results and from what I have said, that typhoid vaccination, at least in the general community, is relatively, but not absolutely, protective. It remains for future investigation to determine in what way the percentages of failures can be decreased.

It seemed to us very important, in our investigations, to devise a method by which the duration of protection could be determined in individual cases. It is all very well to know that on the average vaccination will protect for about two years, but what of the exceptional individual, who from sad experience we have learned is not protected even for two months? Dr. Force and I think we have a method for determining the actual presence or absence of protection in the individual at any given time. This tests consists in rubbing a small amount of material from killed typhoid bacilli on the skin. We have found that nearly all those who have had typhoid fever in the past, and who are known to be usually protected from it, react to this test with the formation of a slight reddish blush about the abrasion. Most people who have been vaccinated within the last two years also react positively. Normal people do not react. We feel justified in assuming that the presence of a positive reaction of this sort is evidence of protection. So far it has not failed us in practise, that is to say, no vaccinated person who has given a positive test has shortly thereafter had typhoid, and conversely in two vaccinated cases where the tests were negative and doubtful, respectively, the individuals have shortly thereafter contracted typhoid fever. It is too early to speak authoritatively about the absolute value of this "typhoidin test," as it is called, but at least we feel justified in urging our vaccinated students to be revaccinated when we find the test negative.

I hope I have somewhere in my remarks suggested to you that results of direct practical bearing are by no means always arrived at directly. In fact the experienced investigator comes to rely more and more on Pasteur's adage of "Chance and the Prepared Mind," and learns to seize chance happenings and turn them to his own ends. I think the evolution of a practical point out of theoretical studies may well be illustrated by some of our recent work. The efficacy of various typhoid vaccines has been tested, as already mentioned, by the ability of each to protect rabbits in a given dose for a given number of weeks against infection with a large dose of living typhoid bacilli. In unprotected animals, or in animals insufficiently protected, these injected

bacilli go on increasing in numbers, and although the animal may live for a considerable period, the typhoid organisms persist in his blood; he has become, in other words, a permanent carrier. In perfectly protected rabbits the bacilli disappear from the circulation within a few hours. It interested us to trace the method by which the bacteria disappear in the protected animals, and we found that coincidentally with the disappearance of the infecting bacteria there occurs a sharp rise in the number of white blood cells in the peripheral circulation. These white cells, leucocytes, or phagocytes, as they are called, are known through the work of Metchnikoff and others to be associated with defense of the body against invading bacteria. This leucocytic crisis, then, would seem reasonably to be associated with protection in these immunized animals. A moderate grade of leucocytosis occurs in the normal unprotected animal, but is apparently insufficient for the purpose. In tracing further the cause of the extreme grade of leucocytosis in the immunized animal, we found it to occur only under specific conditions, that is, only when typhoid bacilli are injected in typhoid immune animals, and not when typhoid bacilli are introduced in normal animals, or other bacteria in our immunized animals. It seemed reasonable, then, to think it might be due to the action of the specific immune bodies which circulate in immune animals and are known to increase phagocytosis by their action on the bacteria with which they unite and which they render more attractive to the leucocytes. This hypothesis we were able to verify by injecting bacteria that had been previously treated with typhoid-immune serum into the circulation of normal animals. The same phenomenon of specific hyperleucocytosis also occurred under these conditions.

Since this hyperleucocytosis is coincident with, and apparently the cause of, the body's ridding itself of bacteria, it seemed possible that the artificial production of it in typhoid fever might cure or beneficially affect this condition, which is so characteristically accompanied by a proliferation of bacteria in the blood stream. We tried out this possibility in our carrier rabbits, those animals in which we had produced a septicemia by injecting living typhoid bacilli. In some cases we cured these animals of their septicemia, and then after testing the harmlessness of large doses of our sensitized vaccine in rabbits and monkeys, even when injected directly into the blood stream, looked forward to a cautious adaptation of our results in cases of human typhoid fever.

It was nearly a year before we had an opportunity to try this method on human beings. In the meantime the results of other writers in essentially the same direction came to our attention, and further encouraged our hope in the proposed method. It will be necessary at this point to go back a step and consider preceding work that had been done in attempts at a specific cure in typhoid fever, that is to say, a cure attempted in full recognition of the cause of this disease, namely, the typhoid bacillus. Striking success in combating bacterial infections has been met with in certain cases by the application of one or more of three pretty definite methods. Some bacteria, like the diphtheria bacillus, produce their harmful effect in the body by the liberation of poisonous substances known as toxins. In the case mentioned, the disease, when taken in time, can be cured in a really miraculous manner by injecting diphtheria antitoxin, which is simply the serum of horses that have been treated with repeated doses of diphtheria toxin and thereby made to produce antitoxins that neutralize the toxin. Other diseases produce their harmful results largely by multiplication of the

invading microorganism. Such diseases, for example, as epidemic meningitis, can be cured by inoculating serum from animals immunized against its causative agent, the meningococcus. Still other diseases, principally local affections, as, for example, carbuncles, may be treated with considerable success by injecting the causative agent itself; in the example mentioned, staphylococcus. This latter form of treatment, or vaccine therapy, as it is called, builds up an active immunity and leads the animal so to muster his reactive, protecting, forces as to expel the invader.

It is this latter method of vaccine therapy which alone has been used with any success in the treatment of typhoid fever. I have already referred to the hopelessness of affecting the course of typhoid fever in any but a palliative way by the other methods of treatment that have been suggested; the fever may be favorably influenced by the continued use of cold baths, but the duration of the disease is little, if at all, affected by such means. In 1893 Fraenkel began the use of small doses of killed typhoid bacilli injected hypodermically in typhoid fever. For twenty years this treatment has been tried with varying success by many physicians, some of whom have published their results. These results, although at times encouraging, have never convinced the medical world that the method is strikingly successful. The best that may be said of it is that it does no harm, and in the hands of some physicians apparently shortens the disease and prevents some of the unpleasant sequels by which typhoid is so apt to be followed.

During the past two years two innovations have been made which, from the results attained by several observers, and in view of the theoretical studies on hyperleucocytosis to which I made reference, have thrown an entirely new light on the possibilities of vaccine therapy in typhoid fever. These two innovations are, briefly, as follows: First, the administration of the vaccine directly into the circulation, and secondly, the use of a sensitized or serum-treated vaccine instead of the plain bacterial growth hitherto used. These procedures, introduced into practise by Thiroloix and Bardon, and by Ichikawa, respectively, carried out the precise method of treatment that we had already suggested from our experimental results, and fully justified our expectations.

During the past year it has been possible for us to carry out the intended treatment in a number of cases in this vicinity, through the great courtesy of physicians who have allowed us to see their patients and have been willing to accept our suggestions in relation to their treatment. This confidence and cooperation has resulted not only in rapid amelioration in the majority of cases, but through comparative study of the successful with the unsuccessful cases has suggested improvements which may increase the percentage of favorable results.

Let us consider what happens when a killed preparation of sensitized typhoid bacilli is given intravenously in a case of typhoid fever. The introduction of something like one twenty-fifth of a milligram of the vaccine into the circulation is followed in a few minutes by a distinct shaking chill, which is accompanied by a rise of the fever of from one to two degrees. This shaking and fever, which is seldom extreme enough to be very uncomfortable, is accompanied by a fall in the number of white blood corpuscles. Following this reaction the fever rapidly falls so that in from six to twelve hours the temperature has reached normal, or even subnormal. This fall in the fever is accompanied by a rise in the leucocytes, profuse sweating, and a feeling of well-being. The severe headaches, begin-

ning delirium, and other symptoms characteristic of typhoid, disappear, or are markedly ameliorated. Perhaps the most important result produced is that the blood usually becomes free from bacteria following a single injection. In forty per cent. of the cases, this return of temperature to normal is permanent, and the patient remains symptomatically, and to all intents and purposes, well. The temperature may fluctuate for a day or two and then become normal. This forty per cent. of aborted cases, as we call them, actually about twenty-five in our series, were restored to a permanent normal condition within a week after beginning treatment. About twenty-five per cent. more are markedly bettered, but not so rapidly cured; the course of these ameliorated cases is characterized by a permanent drop of say a degree in temperature following each injection, and the average duration of the disease in this category is distinctly shorter than is usual. There remain, however, a third of our cases, which total sixty-two, in which the intravenous vaccine treatment has produced no demonstrable effect. These cases are usually severe ones from the onset and it is impossible to say that the treatment did not prevent an even more serious course than the one observed. At least it may be said that the treatment does no harm in these cases, and is followed by temporary abatements of fever and symptomatic benefit. There is a significant blood picture in this class of unaffected cases; they are found to differ from those that are benefited by the treatment in the weakness of antibodies present in the serum. Mention has already been made as to the occurrence and diagnostic value of certain of these antibodies or agglutinins in typhoid fever. We believe from our study that a certain concentration of these antibodies is necessary to assure recovery or benefit after the vaccine injection which, as has been mentioned, produces an increase in the leucocytes. Our present conception of the mechanism of the rapid cure that is frequently produced is that it is due to the combination of these two factors, increased leucocytes and antibodies already present in the body. In other words, when the patient is fighting the infection successfully, a sudden call on his reserves, the phagocytes, finally routs the invader. It may be possible to supply these antibodies when they are lacking by serum from immune animals, and this is one of the many problems connected with this disease on which we are now engaged.

I have tried to lead you into full view of the firing-line of the forces attacking typhoid fever. You will perceive that much remains to be done in the line both of prevention and of cure, but you will not fail, I am sure, to share my belief that here is one of the major diseases which will eventually disappear. I have endeavored to show you the vulnerable points in its cycle of development. If individual cases be rapidly cured, much suffering and death will be prevented and great economic loss avoided; the period of dissemination of the disease germs will also be greatly shortened. Again, if comprehensive sanitary regulations safeguard the disposal of excreta from typhoid fever cases, detect and eliminate the carrier, and prevent the contamination of food and drink, the continuity of the disease will also be interrupted. Thorough prophylactic immunization of large or entire communities will not only protect most of the vaccinated individuals, but prevent foci for further spread of the disease.

You will appreciate the inequality in the utilizable knowledge of typhoid fever that has been acquired through the two different types of medical advance. The purely observational, bedside, clinical progress, resulted, after the lapse of centuries, in cri-

teria on which a differential diagnosis could be made with considerable accuracy; in certain observations from which not wholly convincing conclusions were drawn as to the spread of the disease, and certain methods of palliative symptomatic treatment like hydrotherapy, and more recently, increased feeding. Contrast with this the advances during the last thirty-five years, which marks the era of bacteriology. The parasitic cause of the disease was determined. The demonstration of this microorganism gave us a means of certain diagnosis of the disease; threw light on the nature of the disease process itself; conclusively settled its method of spreading; and has given the only efficient means for specific prevention and therapy.

You will be convinced from this example that advances in applied medicine lie through laboratory investigation rather than through observations made at the bedside, at least in so far as the infectious or parasitic diseases are concerned. Equally persuasive data, from the laboratory standpoint, could be given in relation to the diseases of disturbed metabolism which involve the sciences of chemistry and physiology. You will further readily believe from the complexities of this one problem that I have tried to suggest, that successful prosecution of work of this sort may well monopolize the attention of a large group of workers. The number of these workers is limited only by the opportunities that are available; a reserve supply of eager and potentially productive minds is always at hand. The work itself is, however, not self-supporting, such advances as we may be able to make in the prevention and cure of disease bringing no pecuniary reward. It is fortunate indeed for our welfare that the contributions to human health are not patented as are contributions to human comfort and luxury.

The opportunities for advances in the medical sciences come, in part through private benefaction, in part through public funds wisely administered, when, as in this university, opportunities are given not only for the dissemination of acquired knowledge, but also for its advancement. This ulitization of public funds for any particular research is justified, apart from any preconceived notion as to its promise of practical reward.

Frederick P. Gay
University of California

## CHARLES WILLARD HAYES

The geologist, geographer and explorer, known to colleagues and friends as "Willard" Hayes, died, after a long illness, at his home in Cleveland Park, Washington, D. C., February 8, 1916. He was fifty-seven years old, and in the twenty-eighth year of his professional career.

Hayes was born at Granville, Ohio, graduated at Oberlin (A.B.) 1883, and received his doctor's degree at Johns Hopkins University in 1887. His entry, in the same year, to the scientific staff of the U. S. Geological Survey was, as with most young men joining scientific bureaus of the government, a continuance of the student and research life. Hayes's studies were destined to contribute to a fuller understanding of the principles of geology and physiography; to better the methods of geological investigation and to make more practical, as well as more comprehensive and thorough, the application of geology to economic problems.

The first assignment of Hayes was as assistant to Russell, who, under the direction of Gilbert, then chief geologist, was making a general geologic section across the southern Appalachians. After a year of apprenticeship Hayes succeeded Russell, and began the areal geologic mapping, which he had satisfied himself was the only way to solve the complex structure of this region. It was in the course of this work that he demonstrated, in the folded strata, the existence of flat overthrust faults some of which have a horizontal dis-

placement of several miles, and proved that they are characteristic and essential features of Appalachian structure where the thrust was concentrated on a single fold. The discovery of these faults, the importance of which was first recognized by Hayes, and their coincident mapping in another area by Keith, with subsequent fuller elaboration by Keith, Willis and Campbell, established what may, in effect, be regarded as a geologic principle that has influenced the interpretation of geologic structures in many other parts of North America.

Meanwhile modern physiography, largely an American product, which was then being organized and made a science by Powell, Gilbert, Russell and Davis, found an enthusiastic disciple in Hayes, who, with Campbell, began to apply the principles of the new science in the interpretation of the surface features of the field in which he was at work. Their first paper, "Geomorphology of the Southern Appalachians," published in the *National Geographic Magazine,* is regarded generally as the standard work on the physiography of the region covered, and as having laid a broader foundation for physiographic investigation in general.

In 1891, Hayes participated as geologist in an Alaska expedition by Lieut. Frederick Schwatka, during which a region between the Yukon and Copper Rivers, not previously seen by white men, was traversed with topographic sketching and observations on the geology, geography and mineral resources. Some results of this, at that time very difficult exploration, including data on the northern limit of Pleistocene glaciation in Alaska, on recent volcanic activity, and on the distribution of gold and copper in the region, were contributed in the *National Geographic Magazine* for that year. To the insight then gained by Hayes of the possibilities of mineral wealth in Alaska which then was little known, was due, in no small part, the organization, later, by the Geological Survey of the systematic investigation of the geology and mineral resources of Alaska.

As Hayes became more strongly identified in the economic work of the Geological Survey, more attention was given by it to the systematic investigation of the non-metalliferous and the fuel mineral resources of the country. As a result of his special interest and personal accomplishments in this department of the survey activities, he was, in 1899, placed in charge of the newly established Section of Non-metalliferous Resources. In 1902, he was made chief geologist of the survey, in which position he continued until his resignation in 1911.

At the request of the military governor of Cuba, Hayes was, in March of 1900, detailed to make a reconnaissance of the economic geology of that island. The principal results of his observations on the island, supplemented by those of his assistants, T. Wayland Vaughan and A. C. Spencer, were contributed in a report to General Wood.

In response to a request from the State Department, Hayes was, in 1907, detailed to make a geological investigation in Nicaragua and Costa Rica, primarily for the advice of the Nicaragua Canal Commission. Some accounts of this work, which occupied also a part of the following year, were embodied in several papers, chief among which is his report to Admiral Walker, president of the commission, on the "Geology and physiography of a region adjacent to the proposed Nicaragua canal." This is a principal source of information as to the geology of that part of Central America.

On account of the interest taken by citizens of the United States in the important discoveries of oil in Mexico, and of the apprehension as to the effects of these discoveries upon the oil industry of this country, Hayes, in company with David T. Day, was, in 1909, selected to visit the new developments in the southern republic. Following his return to this country, a report was transmitted to the President, a summary of which appeared as a Senate Document (No. 79), stating that the Mexican oils were of fuel grade, being inferior to most of the American oils, and that their principal markets were likely to be found in Mexico itself and in other foreign countries.

In 1910, Hayes was, by request of the War Department, sent to Panama to procure data

relating to the geologic conditions in the Canal Zone and, especially, in the Culebra Cut. A report by him on the causes of the landslides and other failures in the sides of the cut, and of means for their prevention, submitted to the Secretary of War, was, in summary form, included in the President's message to Congress. Hayes's recommendation, which led to the appointment of a geologist to serve regularly with the Canal Commission, was a wise provision and it would appear to be no fault of these geologists that some of the subsequent disasters were not averted.

In 1901, Hayes began the study of the problems of oil and gas geology, his first investigations being in the Coastal Plain of Texas and Louisiana. Largely as a result of this work, and the growing appreciation of the enormous value of the study of geologic structure in the search for oil and gas, Hayes's services were persistently sought by private interests engaged in the development of oil pools. Finally, in recognition of his ability in oil geology and his success in the Geological Survey as organizer and administrator, he was irresistibly solicited to become vice-president and manager of the "Compania Mexicana de Petroleo 'El Aguila,'" a position which, in October, 1911, he resigned from the survey to accept and which he held until the time of his death. In the new service, he recruited a staff of young geologists, with which he was able, with most brilliant economic results, to accomplish, in effect, a geological reconnaissance of about one half of the Province of Vera Cruz, before the abandonment by the United States of Tampico and Vera Cruz, combined with illness and other circumstances, made it necessary for him to leave Mexico and his work unfinished. From this illness he never recovered.

During his career of twenty-four years in the U. S. Geological Survey, Hayes's geologic work, whether as assistant or as chief geologist, was comprehensive, original, efficient and constructive. He examined in detail and mapped the geology of sixteen quadrangles in the southern Appalachian region, for nine of which the results were published in folios of the Geologic Atlas. He made examinations of non-metalliferous deposits, iron ores, and features of geologic importance in many parts of the country. He was the author, alone or in conjunction with other geologists, of seven papers, published in the annual reports, and of thirteen in bulletins of the Geological Survey. A large number of papers were printed in the publications of various learned and professional societies of which he was a hard-working, helpful and productive member. In 1908 the honorary degree of LL.D. was conferred on him by Oberlin.

It was a privilege to be associated with Hayes. With a master mind, he was genial, philosophical and stimulating. With a penetrative insight of men and things, he sympathetically encouraged, steadied, strengthened and put on a higher level the work of his assistants, while to his colleagues he gave friendly criticism, wise counsel, and unstinted and unselfish assistance.

David White

## A SCHOOL OF NURSING AND HEALTH AT THE UNIVERSITY OF CINCINNATI

The University of Cincinnati has taken over the school of nursing and health of the Cincinnati General Hospital and has put it under the immediate direction of the dean and faculty of its college of medicine. The university has already been given control of the laboratories of the hospital and, through its medical faculty, of doing all the medical, surgical and research work at the hospital. Appreciating the service rendered to the people of Cincinnati by the medical faculty, the city authorities requested the university to undertake the direction of the school of nursing and health also. The university will thus be responsible for all of the educational and scientific work of the entire hospital and its various branches. When the new medical college building is completed, as it is expected it will be early next year, the work of the medical college, the pathologic institute and the school of nursing and health will be assembled in one place, as they already are in one organization.

Nursing will become a skilled and learned

profession to a degree far beyond its present attainment. The advance of modern scientific methods of treating the ills of mankind has already forced the issue upon medical training. That inadequate preparation of nurses and exploitation of them by so-called training schools will be eliminated is an inevitable next step. A nurse should have a liberal, broad education in language, history and the social and physical sciences; and she, like the physician and dentist, should keep up with developments in her own and allied professions. Carried out in this way nursing becomes a dignified calling demanding for success a comprehensive university training.

The school of nursing and health is to be made a high-grade institution, not only for training nurses, but for preparing women to do sanitary and social work in both town and country. It will have three kinds of courses and students.

1. A three-year course for nurses, including systematic instruction and cooperative work in the hospital. This course will lead to a diploma in nursing.

2. A five-year course leading to a degree, including two years of study in the fundamental sciences in the university. This is planned to train a higher class of institutional officers, teachers and sanitarians.

3. Special courses for graduate nurses from other hospitals and schools.

The usual preparation demanded of all incoming students will be required for admission to the first two courses. A certificate from a recognized hospital or school will admit to the special courses.

The staff of instructors has been selected, which will be aided by the professors in the medical college. The director of the school is Miss Laura Logan, a graduate of Acadia College and of Columbia University and formerly of the Mt. Sinai Hospital, New York City. Fourteen instructors constitute the present faculty of the school, not including the members of the medical and other university faculties who give the instruction in chemistry, biology, anatomy, physiology, economics, sociology and general subjects. A noteworthy feature is the appointment of a trained psychologist to give instruction in a subject recognized more and more as invaluable to the physician and nurse.

More and more the university is offering opportunities for the higher education of women, following the educational policy of President Dabney. In 1905 the college for teachers was launched, and in 1914 the school of household arts was made a department of the university. The school of nursing and health is therefore a consistent development.

## PRACTICAL WORK FOR STUDENTS OF THE NEW YORK STATE COLLEGE OF FORESTRY

THE forty-three juniors of the State College of Forestry at Syracuse, who have five months between their junior and senior years for practical work, are scattered literally to the four corners of the continent in all fields of forestry work. It is the policy of the college of forestry to give its students the maximum amount of sound, practical training in their four-year course. Too often college students waste their summer vacations. At the end of the freshman year the boys are helped to get into practical work with lumber companies, landscape concerns and wherever there are openings for hard work with experience. The entire sophomore summer of three months is spent in camp on Cranberry Lake. This camp is as much a part of the four-year course as the mathematics or chemistry taught in the college. The junior year then closes on May 1 and the senior year does not open until October 1, giving the juniors five months for practical work along forestry lines. Many of the boys in the college of forestry are earning their own way and this period of five months not only gives them opportunity for securing a lot of valuable experience but it means sufficient funds for carrying them through their final year in college.

Practically every one of the juniors in the college of forestry is working during this summer vacation in some phase of forestry. Eight of them are with the United States Forest Service on national forests, both in the east and the west. These fellows will be engaged on look-out work to detect forest fires, in the

construction of roads, trails and bridges, in forest reconnaisance and mapping, and in other phases of national forest activities.

Seven of the juniors are working with lumber and wood-preserving companies, eight are engaged in landscape forestry and five others in consulting forestry work. In addition two are engaged in city forestry work in New York and the other eleven men are in the state forestry work, in forestry work for themselves or in attending the sophomore forest camp in the Adirondacks. Most of the men are working in New York state in some phase of practical forestry work, although the school has become national in its activities inasmuch as it draws students from practically all of the states of the union. Its graduates and the juniors who are seeking temporary work only have so far had opportunities to engage in work all over the country, although it is probable that the largest number will remain in this state.

This season the boys who have gone out from the college of forestry for work have secured positions paying from $40 to $100 per month and expenses. Many of the temporary positions lead to permanent work upon graduation from the college. Many calls have come to the college for men and it has been impossible to send them out owing to not having men with a sufficient amount of training. This situation is evidence of a growing interest in forestry and proves that more men will be needed in the future for the protection of our great forest areas and in the development of the industries dependent upon the forests.

## STANFORD UNIVERSITY ARBORETUM

The Stanford Arboretum, comprising approximately 200 acres, and established by Senator Stanford in 1882, has been placed under the control of the department of botany with a view of more fully utilizing it for scientific purposes. An annual appropriation is to be made for the acquisition of specimens, that for the current year being $1,000.

The original collections, which will form the nucleus of the new plantings, contain several hundred species, representing about sixty families. The collection of conifers is especially rich in genera. Including both the Taxaceæ and Pinaceæ, this group of plants is represented by nineteen genera.

As the climate at Stanford is warm enough in winter for orange and lemon trees and cool enough in summer to successfully grow the white pine and Norway spruce, it should be possible to grow almost any species of the temperate and subtropical zones. Plants from Australia, New Zealand, Chili, South Africa and the Mediterranean region are well adapted and will thrive without being watered during the dry season. With such excellent natural conditions the Arboretum should become eventually one of the most extensive collections of arboreal plants. A feature that is to be given especial attention is the West American section. In a tract, set aside for this purpose, it is planned to bring together as complete a collection as possible of the native trees and shrubs of the Pacific coast, Great Britain, Rocky Mountains and the arid southwest.

The development of the Stanford Arboretum along broad scientific lines is meeting with enthusiastic approval and support. Among those who have taken interest in its establishment and offered to contribute toward the building up of the collections are: Dr. C. S. Sargent, director of the Arnold Arboretum of Harvard University; Dr. N. L. Britton, director of the New York Botanical Garden, and Dr. David Fairchild, in charge of foreign seed and plant introduction, United States Department of Agriculture. Mr. H. A. Greene, president of the Monterey Tree Growing Club, has presented already nearly 200 species, many of which are rare and impossible to obtain through ordinary trade channels.

Mr. John McLaren, superintendent of Golden Gate Park, has taken an active interest and has consented to assist in the general planning, especially along the principal avenues. Mr. McLaren's success with the landscape gardening in Golden Gate Park and at the Panama-Pacific Exposition assures the Arboretum the very best advice for its landscape architecture.

Coincident with the new policy of the Arboretum the university has set aside several tracts

on the Palo Alto estate for the preservation of the native vegetation. These plant reserves embrace several hundred acres and contain a variety of plant formation, such as stream-bank, redwood cañon, oak-madroña forest, serpentine outcrops and chaparral. In a preliminary survey of the reserves 64 species of native lignescent plants were catalogued.

## SCIENTIFIC NOTES AND NEWS

SIR WILLIAM RAMSAY, the distinguished British chemist, died on July 23, in his sixty-fifth year.

AT the annual meeting of the Royal Society of Arts on June 29, two weeks before the death of Elie Metchnikoff, it was announced that the Albert medal of the society for the current year had been awarded to him "in recognition of the value of his investigations into the causes of immunity in infective diseases, which have led to important changes in medical practise, and to the establishment of principles certain to have a most beneficial influence on the improvement of public health."

THE Royal Society of Edinburgh at its meeting of July 3, elected foreign honorary fellows as follows: Professor C. Barrois, professor of geology and mineralogy, Lille; Professor D. H. Campbell, professor of botany, Leland Stanford University; Professor M. E. Gley, professor of physiology, Paris; Professor C. Golgi, professor of anatomy, Rome; General W. C. Gorgas, U. S. Army; Professor G. B. Grassi, professor of comparative anatomy, Rome; Professor E. C. Pickering, director of Harvard College Observatory; Professor E. Warming, emeritus professor of botany and keeper of the Royal Botanic Gardens, Copenhagen.

SIR GEORGE T. BEILBY, F.R.S., the chemist and metallurgist, Mr. Edward Dent, Sir Robert Hadfield, F.R.S., the metallurgist, and Sir H. Capel Holden, F.R.S., the electrical engineer, have been elected to the council of the Royal Society of Arts.

THE Earl of Selborne has resigned the office of president of the British Board of Agriculture and Fisheries.

THE prize fellowship, offered by the English Federation of University Women to encourage research, has been awarded to Dr. Alice Lee, fellow of University College, London, who proposes to undertake an investigation into the birth-rate as affected by present conditions.

DR. VICTOR V. ANDERSON has been placed in charge of a medical department and psychological laboratory in the Boston police court established by the city council on June 23.

DR. WILLIAM S. O'NEILL SHERMAN, Pittsburgh, has started for Europe, where he will do research work in war hospitals for the Rockefeller Institute. He is to make a special study of gangrene, tetanus and amputation.

THE Department of Botanical Research of the Carnegie Institution of Washington will be represented at the sixty-eighth meeting of the American Association by Drs. Forrest Shreve and H. A. Spoehr.

ZOOLOGICAL investigations are being conducted this summer by the department of forest zoology of the New York State College of Forestry at Syracuse, on the following lines: The fish survey of Oneida Lake is being continued by Dr. C. C. Adams and Professor T. L. Hankinson, assisted by Mr. A. G. Whitney. Mr. Frank C. Baker is continuing his study of the relation of molluscs to fish. Professor H. N. Jones, bacteriologist of Syracuse University, is studying the diseases of fish. Professor P. S. Welch, of the Kansas State College, is working in cooperation on the annelid worm fauna of the lake and on the fish food in the water lily zone. Through a grant by Hon. R. M. Barnes, of Lacon, Ill., also cooperating with the college, P. M. Silloway is making a survey of the bird life in the forests about the Summer Forest Camp at Cranberry Lake, Wanakena, N. Y.

THE Board of Scientific Directors of the Rockefeller Institute for Medical Research announce the following promotions and appointments: Dr. Alphonse R. Dochez, hitherto an associate in medicine, has been made an associate member. Dr. Henry T. Chickering

has been appointed resident physician in the hospital to succeed Dr. Dochez. The following have been made associates: Dr. Louise Pearce, pathology and bacteriology; Dr. Frederick L. Gates, pathology and bacteriology. The following have been made assistants: Dr. Oswald Robertson, pathology and bacteriology; Ernest Wildman, chemistry. The following new appointments have been made: Dr. Rhoda Erdmann, associate in the department of animal pathology; Dr. Rufus A. Morrison, assistant in medicine and assistant resident physician; Dr. John Northrop, assistant in the department of experimental biology; Dr. Jean Oliver, assistant in the department of pathology and bacteriology; Dr. Ernest W. Smillie, fellow in the department of animal pathology; Dr. William D. Witherbee, assistant. Dr. Hardolph Wasteneys, hitherto an associate in the department of experimental biology, has, as has already been noted in SCIENCE, accepted an appointment as associate professor of pharmacology in the University of California.

UNDER the auspices of the Botanical Seminar of the Michigan Agricultural College, Dr. William Crocker, of the University of Chicago, gave a public address recently on the "History of Our Present Knowledge of Plant Nutrition."

AT the sixty-fourth annual meeting of the Maine Medical Association, held in Portland, an illustrated lecture on "Experiences of the Layman on a Journey of Three Months in Japan, Korea and China with Three Prominent Medical Men" was delivered by Dr. Wallace Butterick, secretary of the General Education Board of the Rockefeller Foundation.

MR. LEONARD DARWIN gave the presidential address at the annual meeting of the Eugenics Education Society held in London on July 6.

CHARLES WILLIAM HENRY KIRCHOFF, a past-president of the American Institute of Mining Engineers and for many years editor of *The Iron Age,* died on July 23, at the age of sixty-three years.

SIR VICTOR HORSLEY, the distinguished English surgeon, neurologist and author, died on July 16, at the age of fifty-nine years, at Amara, in Mesopotamia, from a sun stroke.

THE death is announced of Prince Boris Galitzin, professor of physics in the Imperial Academy of Sciences, Petrograd, known especially for his work in seismology.

GASTON MASPERO, the well-known Egyptologist, permanent secretary of the Académie des Inscriptions et Belles-Lettres, Paris, died on June 30.

THE twenty-seventh annual meeting of the British Museums Association was held at Ipswich on July 11 and 12, under the presidency of Mr. E. Rimbault Dibdin, curator of the Walker Art Gallery, Liverpool.

SIR WILLIAM OSLER has sent word to a number of American surgeons that there are vacancies for 120 young American medical graduates in the military hospitals of London and its immediate neighborhood. The term of service is six months. There will be a small salary and passage will be paid both ways.

AN isolation hospital having a capacity of forty beds is being erected in connection with the State University of Iowa, College of Medicine. It is reported that $42,000 has been set aside for the construction of the institution.

THE United States Coast and Geodetic Survey vessel *Surveyor,* was launched at Manitowoc, Wis., on July 22. It is a steel steamer of about 1,000 tons displacement, with triple expansion engines, and will use crude oil for fuel. Sixty-six officers and men can be accommodated. The vessel can carry enough fuel and stores to remain at sea for three months. The *Surveyor* is held to be the most modern type of vessel ever built for surveying purposes, and will be used for work on the Pacific coast and Alaska. It is intended that she shall be finished this fall in time to leave the Great Lakes before the close of navigation. Miss Elizabeth Brent Jones, daughter of the superintendent of the Coast and Geodetic Survey, named the vessel.

THE results of a large number of recent physical tests of road-building rock have been published by the U. S. Department of Agri-

culture as a professional paper, Bulletin 370. These tests have been made by the Office of Public Roads and Rural Engineering to give highway engineers information in regard to the various physical properties of the different rocks most frequently used in road construction. The three most important of these properties are defined in the bulletin as *hardness,* or the resistance which the rock offers to the displacement of its surface particles by abrasion; *toughness,* or the resistance which it offers to fracture under impact; and *binding power,* or the ability which the dust from the rock possesses, or develops by contact with water, of binding the large rock fragments together.

A POSTAL vote was recently taken of the members of the British Institution of Electrical Engineers on the proposed exclusion of alien enemies, and the details of the result were as follows: Cards issued, 3,244; cards returned, 1,470. In favor of (*a*) to expel members who are subjects of enemy-countries or states, 1,320, against, 88; in favor of (*b*) to expel members who, being naturalized British subjects, have retained enemy nationality, 1,307, against, 79; in favor of (*c*) not to expel members who are naturalized British subjects and were formerly subjects of a country or state now at war with Great Britain and Ireland, but who have under the laws of such country or state definitely lost their alien nationality, provided they are able to prove this to the complete satisfaction of the council, 1,081, against, 264; in favor of (*d*) that no person shall after the —— of ———— 19—, be eligible for election as a member of the Institution who is a subject of any country or state with which the United Kingdom of Great Britain and Ireland is or shall have been at war on or after the date mentioned, 1,120, against, 200.

ONE of the provisions of the federal aid road bill, which was signed by the President on July 11, appropriates $1,000,000 a year for ten years to be spent by the Secretary of Agriculture for the construction and maintenance of roads and trails within or partly within the national forests. The bill provides that, upon request of the proper officers of the states or counties, the money shall be used for building roads and trails which are necessary for the use and development of resources upon which communities within or near the national forests are dependent. The work is to be done in cooperation with the various states and counties. Not more than 10 per cent. of the value of the timber and forage resources of the national forests within the respective county or counties in which the roads or trails will be constructed may be spent. Provision is made for the return of the money to the Treasury by applying 10 per cent. of the annual receipts of the national forests in the state or county until the amount advanced is covered. Officers in charge say that the bill will make possible the construction of many roads which are greatly needed. Since 1913 ten per cent. of the receipts of the national forests have been used in road and trail building, but the funds have been inadequate to meet the needs. Many isolated communities within the national forests are entirely dependent on the government roads and trails. In some instances these settlements are said to be almost entirely without means of communication. According to Forest Service officials the money now made available will permit the construction of many roads necessary to open up inaccessible territory, and will greatly facilitate the development of large areas. It is said that detailed plans covering the policy to be followed in building roads are now being made.

## UNIVERSITY AND EDUCATIONAL NEWS

THE jury in the Surrogates' Court of New York City has declared invalid the will of Amos F. Eno, according to which Columbia University was made the residuary legatee and would receive an amount estimated at over four million dollars. It is understood that Columbia University will seek to obtain a new trial.

THE merger of the medical school of the University of Pennsylvania and the Jefferson Medical College will not be consummated this year. The following statement was made by

a dean of one of the institutions: The members of the United Medical Committee, in charge of the medical school of the University of Pennsylvania and the Jefferson Medical College, of Philadelphia, have agreed that it is advisable to postpone the consummation of the union agreed on by the plan adopted by the trustees of the two institutions, in order that further opportunity may be afforded for considering a number of important matters relative to the mode of administration of the new school, and have, therefore, determined that each of the schools shall conduct, separately from and independently of the other and of the United Medical Committee, the work of its college term for 1916–17.

Professor Walter S. Hunter, of the University of Texas, has been appointed professor of psychology in the University of Kansas, to fill the vacancy caused by the removal of Professor Robert M. Ogden to Cornell University.

At Indiana University, Professor W. N. Logan, director of the school of general science in the Mississippi Agricultural and Mechanical College, has been appointed associate professor of economic geology; and Mr. C. A. Malott has been appointed instructor in physiography and geology. Dr. J. J. Galloway, instructor in paleontology, has accepted a position as curator of paleontology at Columbia University.

Harrison R. Hunt, Ph.D. (Harvard, '16), has been appointed instructor in zoology in West Virginia University. He takes the place of J. Theron Illick, who will sail for China in the autumn to accept a teaching position there.

At the Michigan Agricultural College, Mr. G. R. Johnstone has resigned his instructorship in botany which he has held for three years, in order to prosecute his studies further. The vacancy has been filled by the appointment of Mr. H. C. Young, who was at the Missouri Botanical Garden last year.

We learn from *Nature* that the Manchester City Council (governing body of the Manchester School of Technology) has established a new subdepartment of the school of postgraduate study and research in coal-tar products and dyestuffs, and has appointed Professor A. G. Green, F.R.S., to take charge of it. Professor Green recently resigned the chair of tinctorial chemistry at Leeds University in order to direct the research department of a firm of dyestuff manufacturers. His subdepartment will be under the general direction of Professor Knecht, who is head of the department of applied chemistry, and is expert in the use of dyestuffs, as Professor Green is expert in their manufacture.

It is announced in the London *Times* that Dr. A. E. Evans, lecturer in chemistry in University College, Reading, has been placed in charge of a new department of the Huddersfield Technical College for special study and research in coal-tar color chemistry. It is expected that a number of scholarships will be tenable in the department. The directors of British Dyes (Limited) are supporting the scheme, and are prepared to contribute substantially towards its institution. At Leeds University there is already a department of color chemistry and dyeing, the endowment of which was provided by the Clothworkers' Company.

## DISCUSSION AND CORRESPONDENCE

### AN ENGINEER'S IDEA OF ENERGY

To the Editor of Science: In a recent number of Science[1] Professor Kent takes exception to some criticisms of mine on the "current definition of energy." In his opening sentences he states that in seeking "some language in which to convey to students an engineer's idea of energy" he wrote: "Energy, or stored work, is the capacity for performing work" and proceeded to extend and illustrate his definition.

Now if he had only "stuck to his idea" and prefaced his statement in his book with the words he here uses in his above explanation, so that his statement would have read: "An engineer's idea of energy, or stored work, is the capacity for performing work, etc.," no one could have taken exception to his statement. It would have been *true* and, except by other engineers, not open to dispute. But when he

[1] June 9, 1916, p. 820.

assumes that his statement is a generalized one and offers it as a "definition" of energy and not as a mere statement of the meaning he wishes to have attached to a term, he lays himself open to criticism. For it *is not true* as a general definition. The quoted statement from Maxwell to which I gave my approval, but which he condemns, shows a Maxwellian conception of energy. Professor Kent, himself, shows the futility of attempting to throw the Maxwellian conception into the form of a "definition." Professor Kent rejects the idea, or conception, of Maxwell because he can not throw it into the form of a "definition"; on the contrary, I reject the "definition" because it does not in any adequate way represent Maxwell's conception. Professor Kent seems to think that the statement which I quoted from Maxwell and which met my approval does not rise to the dignity of a conception because it does not fit his (Kent's) definition.

Further on, referring to matter and energy, Professor Kent declares:

> But there is a necessity for definitions of both these terms. The users of my book demand them.

The *naïveté* of this statement is delightful. I thought I was discussing a question of science and logic; Professor Kent seems to consider it one of "commerce and finance." However, in the opening paragraph, above, I have shown how he can "define" to his heart's content by merely specifically stating that such and such are the meanings that he wishes to have attached to the terms he uses and then use them consistently himself. When, however, he invades the fields of science and logic he must expect to be judged by the canons that hold in those fields. That is to say, other writers also use the terms matter and energy, but in a more general sense than is customary, or necessary, with the engineer. Professor Kent can not justly deny to others (Maxwell, for instance) a freedom which he claims for himself. It thus happens, of course, that different writers may use the same term in different senses, but that is a small thing compared to what happens when one and the same writer uses a term in two or more senses without perceiving that he is "mixing things up." It was not "definitions" *per se* to which I was objecting in my former communication, but to lop-sided, inadequate, or misleading statements intended as definitions, but which can result only in confusion and contradictions. Every writer is, and should be, free to "define" all the terms he pleases, provided only that so long as he continues to use a term he uses it consistently. Then the "survival of the fittest" will ultimately decide whether they survive or perish.

As regards the term "energy," in addition to its figurative meaning in literature it has developed two distinct technical meanings, the engineer's and the physicist's. This would not cause any great difficulty if the two technical meanings were distinctly recognized and indicated as is done with the "pound" in use as a unit in engineering practise. Professor Kent claims priority of use for the engineer's definition of energy. Granted, but priority in use can not justify a claim that the thing which he defines is the same thing as that which the physicist claims is conserved. Such a claim is exactly what I meant when I spoke of "mixing things up," or using the same term for two distinctly different things without recognizing that they *were* different. That Professor Kent's definition is consistent with the doctrine of the conservation of energy can not be admitted for a moment by any one who comprehends the meaning of the term conservation. "The capacity for performing work" *always* diminishes with the doing of work, for it *always* depends upon some existing differences, such as difference in temperature, difference in pressure, difference of level, difference in direction of motion, difference in direction of stresses, or even difference in molecular distribution as in the osmotic cell, which difference disappears when the possible work due to it is done. (Compare with Nernst's law.) The capacity for doing work may disappear entirely without diminishing the total energy of a system one particle. Hence, to claim that the capacity for doing work is conserved is tantamount to claiming that a perpetual motion machine is possible;

and the denial of such a possibility is a fundamental postulate of many writers on thermodynamics. The following statement of the postulate[2] may serve to bring out the significance of the differences referred to above:

> No engine of any kind can by any means be made to maintain continuously or restore and maintain when changed, the state of the system which initially set it in motion; and the difference in the energy state which initially established the motion will disappear the more quickly the greater the activity of the engine.

In reply to Professor Dadourian's objection in Science,[3] I would call his attention to the preceding remarks. In addition I would say that he misinterprets my point of view if he supposes that I am opposed to defining energy. If I knew how I would define it myself. Elsewhere[4] I have stated what I conceive constitutes the laws of energy; and those three laws are as near as I can come to a "definition of energy." If he can produce a definition that will convey the necessary information and not conflict with known facts and laws the scientific world will doubtless welcome it with open arms. The field is open. But a *definition that claims to be general* and leaves out, or even is in opposition to, the most important characteristic of the thing supposed to be defined is worse than no definition at all. The absence of a "definition" does not preclude the clarifying of our thought by diligent study of the thing we wish to define. As an aid to study, a provisional, or partial definition may often be of great assistance as a working hypothesis provided it is recognized as provisional and not allowed to close our minds to evidence and dominate our perceptive powers.

M. M. Garver
The Pennsylvania State College

## "AVAILABLE ENERGY" VS. "ENERGY"

To the Editor of Science: The argument between the scientist and the engineer over the definition of energy is clearly saturated enough to crystallize out the clean-cut definition of "available energy" and leave the indefinite but exceeding rich mother-conception of "energy" for those who shall see more clearly or be able to unite our bewilderment of facts and deductions to a concrete statement.

The communication of Professor Garver in the April 21 issue is both a timely and an excellent critique. Evidently he analyzed the difficulty far better than he constructed a working presentation or Dr. Wm. Kent would not have been able to so well establish himself in the reply of June 9.

That the author of a leading engineers' handbook should express himself as Kent has done may be considered as evidence to demonstrate the narrow conceptions and limited field into which practical men continually fall. From the energy-to-sell point of view there certainly is satisfaction in the Kent definition; but we can not allow Dr. Kent to confine the use of the term "energy" to engineering; the engineer clasps hands with the scientist in every undertaking and acknowledges his past and present effort as components of his own practicability.

The men who have most carefully studied thermodynamics and energy transformations assert that one particular sort of energy manifestation can be designated as *free* energy, *available* energy or by some factor indicating *potential* or *intensity* variation. The "stored work" is to be referred to this sort of energy, but the converse is not true—that all the energy in a given system which may thus be described can be converted into work. With Garver we have to say that a certain amount of work may be done during the *transfer* or adjustment of this sort of energy. Some energy is always lost, as heat when the work is done. We find, then, that Kent is careless in using "energy" where he should say "available energy" and he is inaccurate in assuming that *all* such energy is transformable into mechanical work.

Recent writers often state the matter with much conciseness:

[2] *Journal of Physical Chemistry*, Vol. 15, p. 613 (1911).
[3] June 16, 1916.
[4] *Loc. cit.*

Bryan:[1]

We are thus led to the conclusion that under any given conditions only a limited portion of the energy of a system can be converted into mechanical work. This portion is called the *available energy* of the system subject to the given conditions. In order, however, to completely define the available energy of a system, it is necessary to specify not only the external conditions to which the system is subject, but also the means at our disposal for converting energy into useful work.

Nernst:[2]

If any system whatever is subjected to any desired changes, these are, in general, identified with the following changes in energy: firstly, a certain amount of heat is either absorbed or given out; secondly, a certain amount of external work is either performed by the system or is performed against it; thirdly, the internal energy of the system will either diminish or increase. In general in any event the diminution of the internal energy $U$ must be equal to the external work $A$ accomplished by the system, minus the amount of heat $Q$ absorbed; *i. e.*, the following relation exists:

$$U = A - Q.$$

Rushmore:[3]

From a practical standpoint energy may be classified as *available energy*, or that which can be turned into mechanical energy, *and unavailable energy*, or that which is practically useless for the purpose. To the latter belong the enormous sources of energy stored in the earth's rotation, as well as the interior heat of the earth.

There are several reasons why we shall never return to any former conception of the term "energy" as Dr. Kent in his last paragraph hints might yet be done.

Every new study of the relationships only strengthens the division as made above in the three quotations. This view has been expounded so long and widely and is so firmly established in all collegiate education that there is slight excuse for combating it. It is true that investigation and deduction increase our knowledge of energy without disclosing any ultimate interpretation, exactly as in the case of gravitation, yet the laws of transfer and transformation are always found to hold most rigidly. These laws of the conservation of energy and the degradation of energy are ever becoming more valuable and firmly established.

Recent discoveries and conceptions only render a definition or unqualified statement of what *energy* is more and more difficult.

The development of radioactivity has enormously broadened our field of knowledge on energy and set us irrevocably beyond our past. We find "energy" and "matter" meeting on common ground and know not which from t'other.

The development of quantum theory and the study of radiations again shatter any previous notion of energy and portend that energy ideas of the future must involve some aspect of granularity and distribution function.

All the studies on the constitution of matter and the structure of atoms presage radical change and new methods; in dealing with whole classes of energy we are finding the limits of the application of the gross laws of energetics. It is highly significant to follow the mathematical physicist who with much pains in logic comes inevitably to the conclusion that the ether has infinite energy—a conclusion he will likely abruptly discard as absurd!

With matter, ether and energy as possibly only different aspects of, or approaches to, the same ultimatum, who can imagine that our ideas will ever again fit into the long-discarded and outgrown definition.

Useful work may comprise the chief end of the engineer's effort, but it can do him only good to have ever present the concept that relatively only a negligible part of our energy universe concerns itself with such work. It would certainly be a great misfortune to have a statement about energy so terse as to deny the greatest and most useful of our generalizations.

H. B. PULSIFER
ARMOUR INSTITUTE OF TECHNOLOGY

[1] "Thermodynamics," p. 35, 1907.

[2] "Theoretical Chemistry," trans. of sixth German text, p. 8, 1911.

[3] *General Electric Review*, p. 422, May, 1916.

## "TYPUS" AND "TYPE" IN TAXONOMY

THERE is a general attempt among systematic zoologists and botanists to limit the words "type" and "typical" and their equiv-

alents in other modern languages to their strictly taxonomic meanings, *e. g.*, "type species," "typical genus," "type specimen," rejecting their use in their long recognized more general sense. The attempt to restrict a word in general use to a new technical meaning is always difficult and rarely is wholly successful.

May I suggest a way around the difficulty in the case of these words? If in its strictly taxonomic use the word be given its Latin form, *typus,* there will be no ambiguity. It would accomplish the purpose if all zoologists and botanists would abandon the use of the English words type and typical or their equivalents in other modern tongues, thus avoiding all chance of confusion, but this can hardly be secured. On the other hand, taxonomists, who have in mind the taxonomic conventions, might be expected to conform to a better usage, if recommended, and use only the Latin form for the technical meaning. It is easier to bring taxonomists to this better usage than it is to persuade all biologists to abandon the ordinary non-technical use of the vernacular equivalents of the word *typus.*

Maynard M. Metcalf
The Orchard Laboratory,
Oberlin, Ohio

## QUOTATIONS

### SCIENTIFIC DEVELOPMENT IN RUSSIA

A review, however cursory, of scientific work in Russia during the past two years must take account of two features of outstanding interest and importance. One is the appointment, on the initiative of the Imperial Academy of Sciences of Petrograd, of a commission to investigate and report on the natural resources of the Russian Empire with a view to their scientific and practical development and utilization.

Stated in one bald sentence this may not appear particularly impressive, but looked at through the lens of imagination it is revealed as a stupendous project with far-reaching aims and destined to lead to incalculable results. The prime incentive is the fact that in Russia, as elsewhere, the eyes of the nation have been opened and attention has been focused on what was in times of peace known to many, deplored by some, and passively acquiesced in by all: the extent to which its economic life has been honeycombed by the greater energy, enterprise and initiative of the Germans. It is now realized that this economic dependence, extending to many things which might just as well have been supplied by native industry, went far beyond the limits of a natural and legitimate exchange of products between neighboring countries, and the empire is firmly resolved to make a determined effort to put an end to an intolerable anomaly. Russia stands at the parting of the ways, and we in this year of grace are, it may be, witnessing the economic birth of a nation.

As may be supposed, the development of such a comprehensive scheme to the point of effective utility has not been accomplished without much discussion and some hostile criticism. One critic "doubts if the time is well chosen for embarking on such an ambitious enterprise when the strength of the empire is being taxed to the utmost by this terrible war. The end proposed is highly desirable, but . . . the program is so enormous that the preliminary steps alone will take years, to say nothing of the long interval that must elapse between scientific investigation and practical fruition . . ."; and he goes on to point out many problems to the immediate solution of which the academy might in this crisis more profitably apply its energies. However, the commission has in a surprisingly short time got to work—the first sitting took place only in October of last year—and is issuing a series of monographs, several of which have already been published, each written by a specialist, dealing, by way of a commencement, with the vast field, in many directions undeveloped, in others lying fallow, of Russian mining and metallurgy.

The other item of interest is the convening of a conference by the Imperial Academy of Sciences to consider the proposal to found a Russian Botanical Society with its own official journal. There is a great deal of botanical investigation carried on in Russia by various

institutions scattered all over the country, but it is felt that great advantage would accrue from coordination and centralization, and that the founding of such a society is only the just due of the importance of Russian botany "in view of the eminent position which Russia is destined to occupy after the war."

But side by side with these special activities, which are the direct outcome of the quickening of the nation's pulse, there is, as in normal times, a great amount of quiet, unobtrusive research in the domains of biological and physical science. Though there may be no epoch-making discovery to record, there is scarcely a field of mental activity left untilled. Many a peaceful backwater is being navigated undisturbed by the clash of arms, and it is pleasant to read of ethnographical and philological investigations, or of an expedition to the Jablonovy Range to study the local fauna, with its picturesque account of explorations in steppes, morasses and virgin forests. It is interesting to note, in this connection, that there is scarcely a provincial town of any importance in Russia without its medical society and association of local naturalists, or, as the charming Russian idiom has it, "lovers of nature lore," true amateurs in the best sense of the word and all contributing their quota to the common stock. Worthy of mention also are the efforts made for the preservation, as far as may be possible in the circumstances, of valuable treasures of art, science and archeology in the war-zone, such efforts not to be confined to the limits of the empire, but to be extended to enemy territory occupied by Russia. It is pointed out that priceless products of human culture may be saved if timely measures be taken, and to this end the service of various scientific experts has been secured and the sympathetic cooperation of the military staff enlisted.

Finally, mention must be made of the decision of the Imperial Academy of Sciences on the question of the exclusion of alien enemies from the list of honorary members. As the result of a conference held in March of last year to consider the matter the academy expresses itself as loath, by such exclusion, to place any obstacles in the way of the resumption after the war of that international cooperation for the progress of science which will, it foresees, play a greater part than ever in the development of European civilization, "when an end has been made of those hegemonistic strivings which, not content with the sphere of politics, have invaded that of science." Truly a dignified attitude, worthy of an august institution which can look back with just pride on well-nigh two centuries of enlightened effort and solid achievement.—*Nature*.

## SCIENTIFIC BOOKS

*X-rays and Crystal Structure.* By W. H. BRAGG and W. L. BRAGG. G. Bell & Sons, Ltd., London, 1915. Pp. i + vii, 1–228.

All physicists who are at all familiar with the magnificent work which in the two short years between October, 1912, and October, 1914, W. H. and W. L. Bragg did in unfolding the nature of X-rays, revealing the structure of crystals and in laying the foundations for Moseley's brilliant discovery of a relationship between the elements more fundamental than that represented by the periodic table, are agreed that no Nobel prize was ever more justly placed than that which has recently gone to the Braggs. It is the lucid and succinct account of this very new work which constitutes the present book—a book which will always remain a classic, not merely because it is the first book in its field and written by the men who have themselves contributed most largely to the ushering in of the new epoch, but also because it is an unusually fine example of clear, direct and fascinating exposition.

None of the twelve chapters except the fourth, the sixth and the last contain any appreciable material other than that which the authors themselves have contributed. Despite the generous and deserved recognition which they make of the part which Laue played in starting their studies, it is very largely to the Braggs that the world owes the creation of the new subject of X-ray spectrometry, and so long as young men are appearing in England of the caliber of W. L. Bragg and of Moseley, the latter of whom at the age of twenty-seven

had turned out as fine a piece of work as has appeared in fifty years, so long will English physics remain preeminent.

The first chapter reviews briefly the older theories of X-rays and presents Laue's discovery and photographs. The second presents the Bragg theory of the diffraction of X-rays, the third describes in detail the Bragg X-ray spectrometer, the fourth is a brief account of the properties of X-rays. The fifth merely describes crystal structure, little known to most physicists, and the sixth presents our present knowledge of X-ray spectra, and includes an admirable report on Moseley's work. The remaining six chapters present the Bragg analysis of crystal structure made by means of their spectrometer.

Few books have ever appeared which represent in so high a degree the creative work of the authors themselves.

R. A. Millikan
Ryerson Physical Laboratory

*An Elementary Manual of Radio-Telegraphy and Radio-Telephony for Students and Operators.* By J. A. Fleming, M.A., D.Sc., F.R.S. Third edition. Longmans, Green & Co., 1916. Cloth, 360 pages, 194 illustrations.

This is an excellent elementary text-book on the principles of radio-communication, with enough history inserted parenthetically to add descriptive interest, without sensibly distracting attention from the main line of exposition.

Like all of Dr. Fleming's writings, it is particularly strong on the quantitative side. Nevertheless, the mathematics employed are not difficult.

The book is divided into nine chapters, relating to the following topics: Electric Oscillations, Damped Electric Oscillations, Undamped Electric Oscillations, Electromagnetic Waves, Radiating and Receiving Circuits, Oscillation Detectors, Radio-telegraphic Stations, Radio-telegraphic Measurements, Radio-telephony.

The chapter dealing with radio-telegraphic measurements is particularly good.

A blemish in the didactic method is the use of English units of measure in a few of the examples. The complexity involved in the arithmetic, by reference to such archaic and unscientific units, repels the student more than a transition from English to metric units before attacking the problem, and a final transfer from metric to English units in stating the results.

The book will be of great value to students of radio-telegraphy, and to operators seeking to improve their knowledge of their work on the scientific side.

A. E. Kennelly

*The Institutional Care of the Insane in the United States and Canada.* By Henry M. Hurd, W. F. Drewry, R. Dewey, C. W. Pilgrim, G. A. Blumer and T. J. W. Burgess. Baltimore, The Johns Hopkins Press, 1916. Pp. 497, 30 pl. Edited by Henry M. Hurd, M.D. $2.50.

This is one of the few works in the English language in which the history of a separate branch of medicine has been exhaustively treated. The editor, Dr. Hurd, prior to his election as superintendent of the Johns Hopkins Hospital in 1889 and after, has had a long practical experience in institutional psychiatry, and there is probably no other authority in this country so well fitted for the difficult task delegated to him and his associates. The four volumes of this work, when completed, will comprise no less than a full set of separate histories of all the insane hospitals in the United States and Canada. The present volume, although it professes to deal only with the general history of institutional care of the insane on this continent, is, in reality, an exhaustive history of American psychiatry in all its phases, and is therefore likely to remain the authoritative work on the subject for an indefinite period. In this history, there are no great outstanding names, like those of Pinel or Tuke or Griesinger, unless it be that of a woman, who was the prime mover of our improved institutional care of the insane. The record is one of collectivism, of the patient labors of societies, journals and individual propagandists for the good of a much-neglected class of human suffering. Matthew

Arnold, under the influence of Renan, ridiculed the "bold, bad men" who frequent social-science congresses; but it was largely through foregatherings of this order, their patient endeavors with legislative bodies, that we get this record

> Of labor, that in lasting fruit outgrows
> Far noisier schemes, accomplished in repose.

The history, from the crude pioneer conditions to the advent of the psychopathic hospital, where insane patients are no longer pauperized or imprisoned but treated as so many cases of acute disease, traces the slow evolution of a definite series of ideas. It begins with the foundation of the Association of Medical Superintendents of American Institutions for the Insane (October 16, 1844), and the subsequent history of this body, which became the American Medico-Psychological Association on June 6, 1893. A careful synoptic account of all the transactions is given. Among the items of note are Luther Bell's original description of phrenitis or "Bell's mania" (1849), the introduction of the famous "propositions" by T. S. Kirkbride (1851), Field's discussion of hæmatoma auris in the insane (1894), a condition which he showed to be identical with the aural deformity found in antique statues of athletes and in modern boxers and wrestlers (*Pancratiastenohr*), and Weir Mitchell's drastic arraignment of the status of American asylums (1894), which, at the time, was adjudged somewhat premature and captious by our alienists. A chapter on the history of the *American Journal of Insanity* (founded 1844) is followed by chapters on the early and colonial care of the insane, the evolution of institutional care, of the administration of hospitals and their construction, of training schools for nurses and attendants, of state and private care, of the psychopathic hospital and of legislation, the latter part of the volume being taken up with the psychiatric aspects of immigration, insanity in the negro, the Indian, the Chinese and Japanese, the census of the institutional population and the history of Canadian psychiatry. In the Colonies, the psychiatric burden was thrown mainly upon the town councils, which usually meant the pauperization of the insane in county jails, work-houses and almshouses. Under the healthy *plein air* conditions of colonial life, this burden was probably light. It is of record that a large donation for an asylum was declined by colonial Boston on the ground that there were no insane to put in it. In Maryland and Virginia, the custody of the pauper insane and the poor was delegated to the Established Church. The first state hospital (incorporated 1768) was opened at Williamsburg, Va., in 1773. The "era of awakening" (an important chapter) came slowly. It comprised the erection of such hospitals as the Bloomingdale Asylum (1821), the McLean Hospital (1818), the asylum at Lexington, Ky. (1824), the Hartford (1828), and Brattleboro Retreats (1836), and above all the wonderful propagandist labors of Miss Dorothea L. Dix, of whose life a full account is in preparation by Dr. C. W. Page, of Hartford. This remarkable woman practically created institutional psychiatry in Massachusetts, Rhode Island, New Jersey, through the south and west, and even accomplished much in Scotland and England. Her efforts were based upon most careful investigation beforehand and her success was due to the fact that she was an eminently reasonable person, with the unique power of producing convincing facts and of making unanswerable statements at the right moment. This was something different from the usual course of "making a noise like a reformer." After a brief conference with her, a rough New Jersey legislator said: "I do not want to hear anything more. You've conquered me out and out. I am convinced." In Scotland, where the frowardness of women is eyed askance, she incurred the enmity of the Lord Provost of Edinburgh, beat the hostile official in a midnight race to London, and so impressed the statesmen there, that she secured Queen Victoria's order for two commissions of investigation (1885). In Parliament, the member from Glengarry, Mr. Edward Ellice (Prosper Mérimée's old friend), said that "the commission was entirely due to Miss Dix's exertions"

She was a "moral Columbiad," rather than the "Moral Bully" of Dr. Holmes's aversion.

The principal defect of early American care of the insane was that it was mainly a local enterprise, delegated to counties and county officials, men who had "an eye single to the taxpayer," whose chief aim was to establish a reputation for economy as a means of securing reelection to office, with the result that the county asylums were practically poorhouses. This has been notably the case with the so-called Wisconsin system of county care of the chronic insane (1881), which is the subject of an able critique. State care, by which is meant the proper care of all the insane in the state in a suitable state-supported hospital, as distinguished from state support of a limited number, with the rest in county almhouses, is a plant of recent growth. The earliest state hospitals were those at Williamsburg (1773), Columbia, S. C. (1828), Worcester, Mass. (1833), and Utica, N. Y. (1843). The New Hampshire State Care Act did not become operative until 1913. In this field, New York state leads, with the institutions at Willard, Binghamton, Middletown, Poughkeepsie, Buffalo, Ogdensburg, Auburn, Matteawan and Dannemora. Next to Binghamton in size comes the admirable Government Hospital at Washington, D. C., which, under the able administration of Dr. William A. White, is now a community of over 4,000 persons. The psychopathic hospital, a development of Griesinger's idea of a (university) psychiatric clinic, combines the features of voluntary admission, temporary detention, non-restraint and continuous medical observation and treatment. Such institutions or wards now exist at Albany, N. Y., Ann Arbor, Boston, Waverly (Mass.), Providence, White Plains and Washington, D. C. The best example is the recent Henry Phipps Psychiatric Clinic at Baltimore, under the direction of Dr. Adolph Meyer. England and France have left their mark upon the architecture of our earlier insane hospitals. Later institutions have followed the plan evolved by Kirkbride for the Pennsylvania Hospital which consisted essentially of a large central administration building, with extended wings on each side for the separation of the sexes. Details were governed by the "cast iron rules" of the "propositions," a set of hard and fast regulations evolved by the association (1844–1875) for the construction and organization of asylums (Kirkbride) and the legal management of the insane within them (Isaac Ray). The cottage plan and the farm colony are later developments. Of the Buffalo State Hospital, the most extreme example of the old Kirkbride plan, Dr. Hurd says that "the medical officers must walk a distance of half a mile from the administration building to reach the farthest ward on either side," which suggests the flatboatmen on the Potomac River, who, in poling their craft, walk just twice the distance they travel.

Dr. Hurd modestly regards this work as a source-book for the historians of the future, but it is undoubtedly a permanent history, which may be extended but will hardly be duplicated. The chapters are complete in themselves, the book is well-illustrated and the style is charming in its simplicity, sobriety and its traces of delicate humor. A complete index to the whole work, which may be expected at the end of the fourth volume, will make it invaluable for ready reference.

F. H. Garrison

Army Medical Museum

## PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES

The fifth number of Volume 2 of the *Proceedings of the National Academy of Sciences* contains the following articles:

1. *Differential Equations and Implicit Functions in Infinitely many Variables:* William L. Hart, Department of Mathematics, University of Chicago.

Three problems are handled: First, Certain fundamental theorems concerning a type of real-valued functions of infinitely many real variables. Second, The problem of infinite systems of ordinary differential equations. Third, The fundamental problem of implicit function theory in this field.

2. *The Sex of Parthenogenetic Frogs:* JACQUES LOEB, Rockefeller Institute for Medical Research, New York.

Two frogs obtained by artificial parthenogenesis, one ten months old the other thirteen months old, were found to be males, and the thesis that animals produced by artificial parthenogenesis are males is thus further corroborated.

3. *De Vriesian Mutation in the Garden Bean, Phaseolus Vulgaris:* J. ARTHUR HARRIS.

The origin of the new race of beans seems most logically explained as a case of de Vriesian mutation. In this race the whole morphological organization of the seedling has apparently been changed and the race is characterized by a high degree of variability.

4. *Studies of Ductless Glands by the Electrical Method:* W. B. CANNON, Laboratory of Physiology, Harvard University.

The nerves distributed to the thyroid cells belong to the sympathetic and not to the vagus supply, and their effects are not indirect through alterations of blood flow. They are true secretory nerves.

5. *The Distribution of the Chondriosomes to the Spermatozoa in Scorpions:* EDMUND B. WILSON, Department of Zoology, Columbia University.

The chondriosome-material having the same origin, fate and (presumably) physiological significance may be distributed to the germ-cells by processes widely different even in nearly related animals. In one of the scorpions the distribution is effected by a definite process of division, in the other by an operation that has at least the aspect of a hit-or-miss segregation, and one that gives only an approximate equality of result.

6. *New Data on the Archeology of Venezuela:* HERBERT J. SPINDEN, American Museum of Natural History, New York.

Stone implements, including celts, pestles, etc., vessels and figurines of clay with painted and modeled decorations, personal ornaments of shell, nephrite, jet, and serpentine, as well as the petroglyphs and pictographs, occur in considerable quantity. The plastic art of Venezuela is one and the same with the "archaic art" already known in Central America and Mexico.

7. *Note on the Phosphorescence of Uranyl Salts:* EDWARD L. NICHOLS, Department of Physics, Cornell University.

For the only examples of luminescence which admit of detailed inspection, the spectrum of phosphorescence is identical with that of fluorescence and it is suggested that this also applies to all phosphorescent materials. In spite of its great complexity, the luminescence spectrum of a uranyl salt is to be regarded as a unit, all its components decaying at the same rate after the cessation of excitation.

8. *The Pyranometer: An Instrument for Measuring Sky Radiation:* C. G. ABBOT AND L. B. ALDRICH, Astrophysical Observatory, Smithsonian Institution.

Two satisfactory types of this instrument, both derived in principle from the electrical compensation radiation instruments of the late K. Ångström, have been devised. Numerous observations of the sky-radiation have been made. On fine days the sky-radiation alone received on a horizontal surface ranges from 0.07 to 0.13 calories per square centimeter per minute.

9. *Note on Lucas' Theorem:* M. B. PORTER, Department of Mathematics, University of Texas.

A more general result than that obtained by Borel or Polya has been found.

10. *A Variable System of Sevens on Two Twisted Cubic Curves:* H. S. WHITE, Department of Mathematics, Vassar College.

11. *The Neuromuscular Structure of Sea-Anemones:* G. H. PARKER AND E. G. TITUS, Zological Laboratory, Museum of Comparative Zoology, Harvard College.

There are four types of muscle action; they are of phylogenetic significance, and show that the neuromuscular mechanism of sea-anemones is by no means so simple as originally supposed.

12. *Change of the Ionization of Salts in Alcoholic Solvents with the Concentration:* FREDERICK G. KEYES AND W. J. WINNINGHOFF, Research Laboratory of Physical

Chemistry, Massachusetts Institute of Technology.

The present investigation on the conductance of sodium iodide and ammonium iodide in isoamyl alcohol and of sodium iodide in propyl alcohol was undertaken for two purposes: primarily to determine whether in these solvents, somewhat similar in nature to water, salts conform to the mass-action law at very small concentrations; and secondarily, to test further the applicability of Kraus' empirical equation throughout the fairly wide range of concentration employed in the work.

Edwin Bidwell Wilson
Massachusetts Institute of Technology

## SPECIAL ARTICLES

### A NEW MITE FROM THE HAWAIIAN ISLANDS

Recently, while visiting the Hawaiian Islands, my attention was called to a Chinese Litchi (*Litchi chinensis* Sonn.), growing on the grounds of the United States Experiment Station at Honolulu, which was very seriously infested by an apparently new species of mite. The injury caused by this mite is of the familiar erinose type, being produced on the lower side of the leaf. In many instances practically the entire lower surface of a leaf was covered with a light brown erineum, but more often distinct patches of variable size were produced. Badly attacked leaves assumed the general characteristics of peach leaves infected by the leaf-curl fungus (*Exoascus deformans*).

So far as could be learned, the infestation seemed to have been more or less sudden; at least, none was noticed until the injury had become very marked. The tree is considered very valuable and the infestation was so serious as to greatly endanger its life.

It was readily determined that the mite belonged to the genus *Eriophyes*. Specimens of infested leaves were referred to Dr. Nathan Banks through Dr. L. O. Howard, chief of the U. S. Bureau of Entomology. Dr. Banks indicates that the mite is a new species of *Eriophyes*. He also states that, so far as he can find, no mites have ever been recorded from the Litchi, and, further, that very few mites have been recorded from China. There is, therefore, a possibility that the Litchi, although imported from China, later became infested by a mite of Hawaiian origin.

P. J. O'Gara,
*Chief in Charge*
Department of Agricultural Investigations,
American Smelting and Refining Company,
Salt Lake City, Utah,
March 16, 1916

### A POWER CHISEL FOR PALEONTOLOGIC LABORATORIES

The extremely slow, laborious and difficult task of separating fossils from the enclosing matrix, in the old manner, led W. W. Kelley, a senior student of marked mechanical ingenuity, to devise a power chisel, which has been installed in the geologic laboratories of Washington University. Thus far the device has proved so satisfactory to the members of the department that it is thought best to pass the information along to other toilers in the profession.

The chisel proper is extremely simple, consisting of an L-shaped frame in one arm of which is a shaft bearing a balanced eccentric head and, at right angles, in the other, a square plunger holding the chisel point. One blow during each revolution (1,800 a minute) is dealt by the protruding part of the eccentric striking the head of the plunger. A spring holds the plunger away from the eccentric when not in use. The eccentric shaft of the chisel is connected directly to the armature shaft of a one eighth horse-power motor by a

flexible driving shaft, similar to those of the dental engines.

In work upon the larger specimens the chisel frame is held in the hand, the flexible shaft permitting of considerable freedom in manipulation. In the case of smaller specimens, it has been found best to secure the chisel frame in a vise and to hold the specimen in the hand. Putting the chisel in operation consists solely in pressing it against the specimen in the first case, or the specimen against it in the second. Probably of more importance than the speed, is the control of the length of the stroke, and hence of the liability of injury to the specimen. The full stroke is only one fourth of an inch, and by pressing lightly the stroke can be reduced to an extremely small fraction of an inch.

WILLIAM C. MORSE
WASHINGTON UNIVERSITY

## THE OHIO ACADEMY OF SCIENCE

IN accordance with the amendment of the constitution, adopted at the quarter-centennial anniversary in November, 1915, the twenty-sixth annual meeting of the Ohio Academy of Science was held at the Ohio State University, Columbus, Ohio, on Friday and Saturday, April 21 and 22, 1916. Fifty-five members were in attendance.

The presidential address by Professor George D. Hubbard, of Oberlin College, was on the subject "What Has the Future for Geologists?" On Friday evening a joint session of the academy with the Ohio College Association and other affiliated societies was addressed by Professor Charles H. Judd, of the University of Chicago, on "The More Complete Articulation of Higher Institutions with High Schools." On Saturday morning the academy adjourned for a symposium of the Ohio College Association, addressed by representatives of the various affiliated societies. The academy was represented by Professor Lewis G. Westgate, of Ohio Wesleyan University, who spoke on "The Relation of the College to Research."

The remaining scientific program was as follows:

ARCHEOLOGY

"Exploration of Tremper Mound," by W. C. Mills.

BOTANY

"A New Three-Salt Nutrient Solution for Sand and Water Cultures," by A. G. McCall.

"An Adjustment of the Sliding Microtome for Cutting Lignified Tissue," by Forest B. H. Brown.

"Notes on the Structure and Function of the Green Layer of the Bark of Woody Plants," by Forest B. H. Brown.

"The Distribution of Fungi in Porto Rico," by Bruce Fink.

"The Genus *Physcia* in Ohio," by Martha McGinniss, introduced by Bruce Fink.

"A Relative Score Method for Unmeasured Characters," by A. G. McCall.

"The Revegetation of the Katmai District of Alaska," by Robert F. Griggs.

"Decrease of Permeability with Age" (Preliminary Note), by H. M. Benedict.

"Methods of Spore Formation in the Zygnemales," by E. N. Transeau.

"Notes on the Germination of Tree Seeds," by William R. Lazenby.

"The Quince Leaf-Spot," by W. G. Stover.

"A Blade Blight of Corn," by W. G. Stover and W. N. Ankeny.

"The Occurrence of the *Volutella* Rot in Ohio," by Gustav A. Meckstroth.

"Observations on the Ontogeny of the Gall of *Pachypsylla mama* Riley," by B. W. Wells.

"Botanizing in Porto Rico," by Bruce Fink.

"Parthenogenesis in the Dandelion," by Paul B. Sears.

"The Educational Value of Wood Study," by A. B. Plowman.

"A New Method for Marking Slides," by Paul B. Sears.

"Certain Points in the Celloidin Method" (Demonstration), by A. B. Plowman.

ZOOLOGY

"Parallelism between the Cystid Agelacrinites (fossil) and the Holothurian *Psolus* (recent), with Demonstrations," by Stephen R. Williams.

"The Axial Rotation of Microorganisms and its Evolutionary Significance," by L. B. Walton.

"Notes on Ohio Tingitidæ," by Carl J. Drake.

"Insect Population of Grasslands," by Herbert Osborn.

"Genitalia of the Bedbug with special reference to a Unique Method of Copulation," by P. B. Wiltberger.

"The Origin of the Gasserian and Profundus Ganglia in *Rana*," by Ralph A. Knouff, introduced by F. L. Landacre.

"The Fusion of the Gasserian and Profundus Ganglia in *Plethedon*," by Katharine Okey, introduced by F. L. Landacre.

"The Origin of the Placodal Ganglia in *Squalus*," by C. I. Reed, introduced by F. L. Landacre.

"Concerning Thyroid Glands in Amphibia," by R. A. Budington.

"Feeding Thymus and Thyroid Extracts," by E. P. Durrant.

"Notes on Protozoa. (*a*) A Review of the Arcellidæ. (*b*) Supplement to the Euglenoidina," by L. B. Walton.

"Notes on Birds," by H. A. Albyn.

"A Recent Ohio Specimen of Henslow's Sparrow" (Demonstration), by Edward L. Rice.

GEOLOGY

"On Wavemarks," by Walter H. Bucher.

"The Northward Extension of the Physiographic Provinces of the United States," by W. N. Thayer.

"Additions to the Anatomy of *Lepadocystis moorei*," by W. H. Shideler.

"Crystals," by W. N. Speckman.

PHYSICS

"Resistance of Electrolytes by a modification of Kohlrausch's Method," by M. E. Graber.

"Demonstration of Apparatus showing Analogy between Reactance Phenomena in Alternating Current Circuits and in Fluids," by F. C. Caldwell.

"Absorption of High Frequency X-rays," by S. J. M. Allen.

"The Symbols used in Geometry," by John H. Williams.

The trustees of the Research Fund reported a further gift of $250 from Mr. Emerson McMillin, of New York, for the encouragement of the research work of the academy. Since the last meeting a grant to L. B. Walton has been paid, and new grants made to L. S. Hopkins, F. L. Landacre, W. H. Shideler, B. W. Wells and Stephen R. Williams.

Gratifying progress was reported by the committee on scientific journals. The scope of this work, in which the academy is cooperating with the Ohio Library Association, is shown by the following paragraphs from the appeal for cooperation mailed to all important libraries in the state: "The Ohio Academy of Science and the College Section of the Ohio Library Association jointly propose to compile a union catalogue of the periodical and scientific sets (except documents) in the libraries of the state. This catalogue is to be made on cards, and filed with the Ohio State University Library, the official depository of the Ohio Academy of Science. Ultimately the academy hopes to print this union catalogue for the benefit both of librarians and of scientists. However, until printed, it will be possible for any one to write directly to the Ohio State University Library and secure information concerning the location of any scientific set in the state."

"The Ohio Academy of Science has been working on such a proposition for several years, and much of preliminary data has been received. At the October, 1915, meeting of the Ohio Library Association a committee was named to compile a union catalogue of periodical sets so that librarians might know where sets are when needed by them in the various universities and colleges."

"Therefore, this joint effort of the two associations, as outlined above, will bring into existence a bibliographical tool, the value of which will be indispensable to the college librarians and to the scientists of the Ohio Academy."

Obituary notices of Professor F. M. Webster, of Washington, D. C., and Professor John Royer, of Bradford, Ohio, were presented by the Committee on Necrology.

Sixteen new members were elected.

The officers for 1916–17 are as follows:

*President*—Professor F. O. Grover, Oberlin College.

*Vice-presidents*—(Zoology) Professor Stephen R. Williams, Miami University; (Botany) Professor E. L. Fullmer, Baldwin-Wallace College; (Geology) Professor August Foerste, Steele High School, Dayton; (Physics) Professor M. E. Graber, Heidelberg University.

*Secretary*—Professor E. L. Rice, Ohio Wesleyan University.

*Treasurer*—Professor J. S. Hine, Ohio State University.

*Executive Committee, in addition to the President, Secretary and Treasurer, members ex officio*—Professor L. B. Walton, Kenyon College; Professor Bruce Fink, Miami University.

*Trustees of Research Fund*—Professor W. R. Lazenby, Ohio State University; Professor N. M. Fenneman, University of Cincinnati; Professor M. M. Metcalf, Oberlin College.

*Publication Committee*—Professor J. H. Schaffner, Ohio State University; Professor L. B. Walton, Kenyon College; Professor J. A. Culler, University of Cincinnati.

*Library Committee*—Professor W. C. Mills, Ohio State University; Professor F. O. Grover, Oberlin College; Mr. C. W. Reeder, Ohio State University.

Edward L. Rice,
*Secretary*

Delaware, Ohio